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ERRATA

[NOTE.—Slight errors have been corrected in the Index.]

Page
35, line 7, read TAITENSIS.
43 „ 31, for *Œstrelata* read *Æstrelata.*
58 „ 28 „ *monaria* „ *pulmonaria.*
61 „ 20 „ *canaliculata* „ *calicaris* var. *canaliculata.*
63 „ 19 „ *furctata* „ *furcata.*
68 „ 8 from bottom, delete the comma after *Spiræa.*
79 „ 31, for *non-scriptum* read *non-scriptus.*
119 „ 17, read ÆRUGINOSA, Mudd.
149 „ 17, for *Ptilota* read *Ptilonia.*
175 „ 1 „ E. „ ECTOCARPUS.
180 „ 2 „ *G.* „ *Gracilaria.*
185 „ 19 „ *simulans* „ *similans.*
187 „ 24 „ L. „ LOPHURELLA.
190 „ 12 from bottom, read *Ballia Brunonia*, Harv. in Hook. Journ. Bot. ii. (1840) p. 191, tab. 9; *B. Brunonis*, Hook. f. & Harv. in Fl. Ant. i. p. 190; ii. p. 488.
193 „ 16, for Fosl. read Heyd.
„ „ 19 „ *Lithothamnium* read *Lithophyllum.*
207 „ 4 from bottom, read *Cenomyce.*
223 „ 15, for *floscula* read *Flosculus.*
256 „ 1, read senescence.
279 „ 8, for polyganum read polygamum.
„ „ 9 „ *Wits.* „ *Wils.*
280 „ 13 „ *Desv.* „ *Desr.*
321 „ 18 „ H. „ S.
350 „ 25 „ *nodosus* „ *nodosum.*
369 „ 9 from bottom, for *natans*, L., read *natans*, Börg.
370 „ 9, for *natans*, L., read *natans*, Börg.
372 „ 11 „ *Lyngbia* „ *Lyngbya.*
387 „ 5 from bottom, for A. Sm. read Sharpe.
459 „ 14, for *obtusifolia* read *obtusiloba.*
461 „ 3 „ *melanocarpa* „ *arborescens.*
466 „ 9, read MILLETTIA.

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(BOTANY.)

Structure of the Wood of Himalayan Junipers. By W. Rushton, A.R.S.Sc., D.I.C., Demonstrator in Biology, St. Mary's Hospital Medical School, Paddington, W.; Assistant Lecturer in Botany, South-Western Polytechnic Institute, Chelsea. (Communicated by Prof. Percy Groom, D.Sc., F.L.S.)

(Plate 1.)

[Read 2nd April, 1914.]

The woods of the Indian species of *Juniperus*, *J. recurva*, Ham., *J. Wallichiana*, Hook. f. & Thoms. (syn. *J. pseudo-sabina*, Fisch. & Mey.), *J. macropoda*, Boiss. (syn. *J. excelsa*, Brandis, non Bieb.), and *J. communis*, Linn., are similar in general characters to those of Junipers as a whole, which are distinguished by the annual rings being generally narrow, often unconformable and coalescent on the narrow side. The summer wood is usually thin but dense. The tracheids are wholly without tertiary or secondary spirals.

Resin-passages are wholly wanting, but resin-cells are rather numerous, chiefly in tangential bands, often giving rise to the appearance of secondary growth-rings. The numerous and often resinous rays are chiefly without tracheids, with the ray-cells mostly with coarsely pitted terminal walls. The lateral walls have half-bordered pits, round or oval, in shape arranged in 1–2 rows radially. Fusiform rays are wholly wanting, the rays being mostly uniseriate, occasionally biseriate in parts, and the cells are round, oval, or oblong in shape tangentially. In transverse section in my specimens, the annual rings per inch of radius are lowest in *J. Wallichiana* with 26, and highest in *J. recurva* and *J. communis* with 44, and *J. macropoda* 33.

The amount of summer wood per annual ring in each species is highest in *J. recurva* and *J. communis*, where it sometimes occupies almost half of each ring, or may be reduced to the last 4–8 rows of tracheids up to the outer limit of the ring, whereas in *J. Wallichiana* and *J. macropoda* it rarely occupies more than 2–6 rows from the outer limit of the year's growth. The tracheids are arranged in straight radial rows, square to round in outline in transverse sections in the spring wood, and oblong in the summer wood with the long axis tangential, and show a length of 0·5–3 mm. in all species. Bordered pits occur on the radial walls of both spring and summer tracheids, arranged in a single longitudinal row with occasional pairs in the spring wood, and wholly uniseriate in the summer wood. On the tangential walls of the latter the bordered pits occur somewhat sporadically, but only occasionally on the tangential walls of the spring wood, especially towards their ends, in cases where the tracheids happen to bend or twist about radially. The number of pits per tracheid varies in the different species, being largest in *J. macropoda*, where they are more or less contiguous, and least numerous in *J. communis*, where they are more distant. In *J. Wallichiana* and *J. recurva* intermediate conditions were found with numbers in between. The ends of the tracheids are more or less rounded off except where they happen to end near a medullary ray, in which case they are frequently bent out of their course and run along the upper or lower surface of the ray-cells radially (Pl. **1.** fig. 1), or where two tracheids come together, one from above and one from below, when they are much contorted with the common ends flattened. When this flattening is well marked a bordered pit is invariably present on the common wall (fig. 2).

This bending of the tracheids is of frequent occurrence in all the Indian species, more especially in *J. recurva* and *J. macropoda*.

Lignified bars (Sanio's bars) are numerous in all the species, in some cases running radially throughout the whole width of an annual ring (figs. 3, 4, 5). The bars readily stain with lignin stains such as phloroglucin and hydrochloric acid, etc., whilst above and below the pit-areas the clear unlignified rims (Sanio's rims) so common in pine-wood can be demonstrated, but they are not so numerous or as clear to see as in many of the Pine species.

Professor Groom and myself, working on the East Indian Pines (Journ. Linn. Soc., Bot. xli.), found these unlignified areas to be of a pectic nature, and not cellulose as previously stated by Miss Gerry (Ann. Bot. 1910), so that it was thought worth while to investigate their nature in *Juniperus* so as to find out whether they are cellulose or pectin.

To work out this point, radial and tangential sections were taken of all four species and all submitted to similar treatment, one set of solutions being used throughout. The colourless rims (Sanio's rims) occur in all four species, but in different proportions according to the number of pits per tracheid and their distance apart.

The sections were first put into 1 part HCl to 3 parts absolute alcohol for an hour, then washed with distilled water and left in strong ammonium hydrate overnight to cause the tracheid-walls to swell up. The following day they were carefully washed with distilled water and submitted to the following tests :—

(1) With phloroglucin and hydrochloric acid the rims remained colourless though the walls of the tracheid and Sanio's bars stained a rich red colour.

(2) With iodine and sulphuric acid the rims still remain unstained.

(3) With Congo red no staining of rims.

(4) With Kleinberg's hæmatoxylin, the rims unstained.

(5) With Haidenhain's hæmatoxylin watery solution without mordant, the areas were stained black.

(6) On treating sections with 2 per cent. solution methylene-blue in water followed by a 2 per cent. solution of acetic acid, the rims stained a faint blue colour and the walls of the tracheids a pale green.

(7) On treating sections with freshly-made cuprammonia overnight, then washing with distilled water and submitting to methylene-blue acetic-acid test, the blue colour of the rims was intensified ; on leaving sections in strong ammonium oxalate for 24 hours, negative results were obtained with the blue stain, with Schultze's solution, and with iodine-sulphuric acid.

(8) On treating sections of all species with a freshly-made solution of ruthenium-red, the rims stained red in both radial and tangential sections, appearing as short curved red lines above and below the pits in radial sections and as small red dots in tangential sections (figs. 18, 18 *a*). Results identical with to the preceding were obtained when the sections had not undergone previous treatment for swelling of the cell-walls. From the above tests it appears that in the Indian Junipers, as well as in the Indian Pines, these areas above and below the pits are pectic in nature and not cellulosic *

It was found possible to establish a general parallelism between the number of pits and the number of Sanio's rims per tracheid. Where the pits were numerous the number of rims was found to be correspondingly large (*J. Wallichiana* and *J. macropoda*), whereas in *J. recurva* with fewer

* In a paper recently published by Miss Ruth Holden on "The Jurassic Coniferous Woods from Yorkshire" (Ann. Bot. xxvii. (1913) pp. 533–445, pls. 39, 40) frequent reference is made to the cellulosic nature of "Sanio's bars." The structures there described I have, in accordance with the terminology of Groom & Rushton (Journ. Linn. Soc., Bot. xli. (1913) pp 457–490, pls. 24, 25), designated "Sanio's rims," reserving the name "Sanio's bars" for the lignified bars so frequently found crossing the lumina of the tracheids.

pits a smaller number of rims was demonstrable. Finally in *J. communis*, which shows the smallest number of pits per tracheid, it was only possible to demonstrate an average of one rim for every eight tracheids.

Medullary Rays.

The rays in all four of the Indian species agree with those of the American in being mostly uniseriate, occasionally biseriate in tangential sections, with the cells round, oval, or oblong in outline, and made up entirely of thick-walled parenchyma with simple pits in their upper and lower walls, and half-bordered ones on their lateral walls, 1–4 per wood-tracheid in the spring and summer wood of the various species. Where only 1–2 pits per wood-tracheid occur, they are arranged in a single radial row, but where more occur, in two radial rows one above the other. Often in the summer wood the ray-cells widen out parallel to the long axis of the stem and three pits occur one above the other per summer-wood tracheid (fig. 13). The end-walls of the ray-cells are coarsely pitted in tangential sections, giving the appearance of a network of end-wall interspersed with irregular-shaped pits. The length of the cells is equal to the width of 4–8 spring-wood tracheids and 3–6 summer tracheids radially. Frequently in the summer-wood zone the ray-cells are much shortened and widened out parallel to the axis of the stem and often dovetail into each other.

The height of the rays seen tangentially varies from 1–20 cells in *J. communis*, 1–18 in *J. macropoda*, 1–12 in *J. Wallichiana*, and 1–8 in *J. recurva*.

Resin Cells.

Resin cells occur in all four species, but in different areas of the growth-ring. In *J. recurva* they sometimes occur in a definite zone in the early summer wood, but more frequently they are scattered throughout the late spring and early summer wood, but never extend outwards beyond the third tangential row of summer tracheids from the outer limit of the year's growth. In *J. macropoda*, *J. Wallichiana*, and *J. communis*, they occur in definite zones, but the position of the zone varies. In *J. macropoda* the cells occur up to the outer limit of the growth-ring and never more than 4–6 tracheids away from it, often also occurring in the early spring wood of the following year's growth. In *J. Wallichiana* the resin zone is more often in the middle of the growth-ring and extends up to a limit of six tracheids from the outer boundary, whereas in *J. communis* the zone is more constantly in the middle of the growth-ring and never extends nearer than 20–25 tracheids from the limit of the year's growth. The length and width of the resin cells also vary, being shortest in *J. macropoda*, 65–88 μ long with a width of 3–5 μ radially and 16 μ tangentially, intermediate in *J. recurva* and *J. communis*, 125–200 μ long and 12–15 μ wide radially, and greatest in *J. Wallichiana*,

230 μ long by 27 μ wide. Sometimes the cells occur in pairs, but the width of the two is rarely more than that of a single normal cell. In normal cells the end-walls usually show local thickenings, either solitary in the middle or as a series across the wall.

The lateral walls possess pits which are mostly simple on the radial and bordered on the tangential walls, with occasional bordered ones on the radial walls. Where the pits are bordered they are round with an oval orifice, and similar to those occurring on the tangential walls of the summer tracheids.

In none of the four species do the resin cells form acontinuous longitudinal series, but are interrupted at intervals by ordinary wood-tracheids.

In *J. Wallichiana* in one instance an aggregation of short resin cell-structures appeared to form a resin cyst (fig. 6), but probably this represented a pathological condition.

The position of the resin cells in the growth-ring gives a ready way of identifying the species in transverse section.

Summarising the distinguishing characters of the four species they are as follows :—

	J. recurva.	*J. Wallichiana.*	*J. macropoda.*	*J. communis.*
Growth-rings.	Narrow.	Wide.	Narrow.	Wide.
Number of growth-rings per inch of radius.	44	26	41–42	33
Medullary Rays.				
Distance away from each other tangentially.	1–10 tracheids.	1–12 tracheids.	1–12 tracheids.	1–8 occasionally 10 tracheids.
Height, tangential.	1–8 cells.	1–18 cells.	1–18 cells.	1–20 cells.
Pits on lateral walls per wood-tracheid.	1–4	1–4	1–4	1–4 {mostly 1–2.}
Shape of pits	Round, small, orifice long and slit-like, extending beyond border.	Round, orifice oval, occasionally extending beyond border.	Round, orifice oval, hardly ever extending beyond border.	Round, large, orifice oval, never extending beyond border.
Number of pits on wood-tracheids.	Not numerous.	Fairly numerous.	Very numerous, often touching each other, round to elliptical in shape.	Not numerous.
Resin Cells.				
Occurrence	Somewhat scattered in middle of ring and extending to third row of tracheids from outer limit of growth-ring.	Zonate; occurring between middle of ring and fourth row of tracheids from the outer limit.	Zonate; always occurring up to limit of growth-ring, never more than 4–6 tracheids from limit of year's growth. Sometimes in early spring wood.	Zonate; from middle of ring to a limit of 20 tracheids from outer limit of growth-ring.
Length	185 μ.	230 μ.	65–88 μ.	125-200 μ.
Width	12–15 μ.	27 μ.	3-5 μ rad. 16 μ tang.	12·5–15 μ.

A detailed description is given below of each species and the main points of interest brought out.

JUNIPERUS RECURVA, *Ham.*

The wood of this species is moderately hard and light reddish brown in colour. The growth is slow, in my specimen 44 rings per inch of radius, but Gamble points out that 22 rings per inch is common for Sikkim wood, and twice as many for wood grown in the North-West area.

Macroscopic (naked eye).

The annual rings are well marked off from each other, the summer wood is narrow and dense, and the medullary rays just visible.

Microscopic (tracheids).

The tracheids occur in well-marked radial rows as seen in transverse sections, 22–42 occurring in each row, of which from 8–25 belong to the summer-wood area and the rest to the spring, the latter gradually changing to the former. In some a slight indication of an attempt at double-ring formation occurs very near the outer limit of the year's growth. The bordered pits on the radial wall of the spring tracheids are round and do not touch each other. The orifices are circular in the early spring tracheids (fig. 7), but more lenticular as the summer wood is reached (fig. 8). The pits on the tangential walls of the latter are more scattered, with narrow lens-shaped orifices (fig. 9).

The length of the tracheids is 1–2 mm. as a rule, but shorter ones, 0·5 mm. long, are not uncommon, with a thickness of wall and width of lumen as follows :—

	Width of lumen.		Thickness of wall.	
	Radial.	Tangential	Radial.	Tangential.
Spring wood	20 μ	19 μ	2·5–3 μ	2·5–3 μ
Summer wood..... ...	5–6 μ	18 μ	3–4 μ	3–4 μ

The tracheids do not all run straight, as some, when they come in contact with a medullary ray, bend radially and run along the ray for some distance with their ends more or less pointed (fig. 1), but where they do end abruptly on a ray their ends are flattened. In other cases they follow an irregular course, and where the ends of two tracheids meet a bordered pit occurs between them (fig. 2), and often pits occur on the tangential walls in these areas. Tangential sections in such a region often show large oval spaces surrounded by a lignified wall, which are the bent tracheids cut in an oblique direction (fig. 10), and where these bent tracheids end by the side of a medullary ray they have a tendency to push the ray-cells to one side, causing them to appear irregular in shape instead of round (fig. 11).

Medullary Rays.

The rays occur at a distance of 1–10 tracheids away from each other tangentially and are generally low, fairly wide, and mostly uniseriate. They are made up of thick-walled parenchymatous cells, which in tangential section are round in the middle of the ray and oblong at the upper and lower limit (fig. 14).

Simple pits occur on the upper and lower walls, and 1–4 bordered pits per wood-tracheid on the lateral walls, the latter being small and round with long slit-like orifices extending beyond the border (fig. 12). Four pits per tracheid are most common in the spring wood, being arranged in two radial rows; whereas three pits, arranged one above the other, are usually found in the summer wood (fig. 13), the latter arrangement occurring most frequently where the rays are only one cell high and widened out above and below (fig. 13).

The end-walls are coarsely pitted and arranged either transverse or oblique. The length of the ray-cells is equal to the width of 5 tracheids in the spring wood and 6–7 in the summer, but often in the latter area they are only equal to 2–3 and widened out parallel to the long axis of the wood-tracheids. The whole of the cells are filled with resin as tested with copper acetate and other tests, but it was easy to remove it by leaving sections in equal parts of strong potash and ammonium hydrate overnight.

Resin Cells.

In wide growth-rings the resin cells are very much scattered in the middle of the ring, but where the ring is narrow the resin cells occupy a zone near the beginning of the summer wood and extend to a zone about 3 tracheids from the outer limit.

They show an average length of 185 μ, with a width radially of 12–15 μ. They possess simple oval pits on the radial walls and bordered ones tangentially, the latter being comparable in size to those on the tangential walls of the summer tracheids (fig. 15).

JUNIPERUS WALLICHIANA, *Hook. f.*

Macroscopic (naked eye).

The wood of this species is of a light reddish-brown colour, with the annual rings distinct and fairly equal in extent to each other, showing 26 to the inch radius. The medullary rays are just visible as brown lines.

Microscopic (tracheids).

In transverse sections the tracheids are arranged in radial rows with 35–45 in each row, of which only 4–8 (occasionally 10) belong to the summer

wood, and the rest to the spring. In outline they are square to round in the spring and oblong in the summer wood. When isolated they show a length of 2–3 mm., with width of lumen and thickness of walls as follows:—

	Width of lumen.		Thickness of wall.	
	Radial.	Tangential.	Radial.	Tangential.
Spring wood	29 μ	23 μ	1·4 μ	1·4 μ
Summer wood	5·7 μ	27 μ	2 μ	2 μ

The ends of the tracheids in most cases are rounded off, sometimes forked and flattened where they end on a medullary ray, and occasionally bend and run along the ray-cells as in *J. recurva*.

The bordered pits on the radial walls are arranged in a single series with occasional pairs, but are more numerous and closer together than in *J. recurva*. They are round, with a circular orifice in the early spring wood which gradually becomes lenticular as the summer wood is reached (fig. 16).

Pits also occur on the tangential walls of the summer wood; these have lens-shaped openings like those on the radial walls (fig. 17).

Sanio's bars occur very frequently together with Sanio's rims above and below the pit-areas; they can be demonstrated in both radial and tangential sections (figs. 18, 18 *a*).

Medullary Rays.

These are numerous and wide, occurring at a distance of 1–12 tracheids away from each other tangentially and made up entirely of thick-walled parenchyma, with a length equal to the width of 4–8 tracheids in the spring wood and 3–6 in the summer, with simple pits on the upper and lower walls, 1–4 half-bordered pits per wood-tracheid on the lateral walls, and numerous irregular-shaped simple pits on the end-walls. On the lateral walls the pits are round, with orifices slit-like, slightly wider in the middle, and rarely extending beyond the border (fig. 19).

Tangentially the rays are mostly uniseriate (fig. 20), 1–18 cells high, with occasional biseriate ones (fig. 21); the cells are round in the middle and oblong above and below, and often loosely attached to each other, so that intercellular spaces can be seen in both radial and tangential sections. All the rays are more or less resinous.

Resin Cells.

The resin cells occur in a zonate manner in the late spring and early summer wood, and never occur beyond the fourth row of tracheids from the outer limit of the growth-ring, but occasionally they are scattered, especially in rings which happen to be rather wide.

They attain a length of 230 μ and a width of 26 μ radially, with local thickenings on the end-walls, and bordered pits with lens-shaped openings on the radial and tangential walls (fig. 22). Occasional simple pits occur on the radial walls.

Juniperus macropoda, *Boiss.*

Macroscopic (naked eye).

The wood of my specimen had quite a reddish tint, with 41–42 growth-rings per inch of radius and medullary rays just visible to the naked eye.

Microscopic (tracheids).

Transverse sections show an average of 44 tracheids per radial row in each growth-ring, of which only 2–6 belong to the summer wood and the rest to the spring. On the whole the tracheids seem more loosely attached to each other in this species than in the other three, and show a length of 1–3 mm. with a width of lumen and thickness of wall as follows :—

	Width of lumen.		Thickness of wall.	
	Radial.	Tangential.	Radial.	Tangential.
Spring wood	27 μ	18 μ	1·9 μ	1·9 μ
Summer wood	3·8 μ	15·7 μ	3·8 μ	3·8 μ

The tracheids run fairly straight with the ends bluntly rounded off, except where they end against a medullary ray, when they are flattened or run along the ray. The bordered pits on the radial walls are in a single row and very numerous, touching each other in the early spring wood but further apart toward the summer wood. In outline they are round to elliptical, with orifices round in the early spring wood, but more lens-shaped in the late spring and summer tracheids (fig. 23). The pits on the tangential walls of the latter possess lens-shaped orifices (fig. 24).

Sanio's bars and rims can be demonstrated.

Medullary Rays.

The rays are not so numerous as in the other species, and there is much variability in height : rays 1–2 cells high are numerous, but some are 18 cells high as seen tangentially. They occur at a distance of 1–12 tracheids away from each other, with the cells round in the middle of the ray and oblong above and below (fig. 25). They are made up of thick-walled parenchyma, with simple pits on the upper and lower walls and 1–4 bordered pits per wood-tracheid on the lateral walls. The latter are round with openings never extending beyond the border (fig. 26). The rays are resinous.

Resin Cells.

The resin cells in this species always occur close up to the outer limit of each annual ring, usually on a level with the last three or four tangential rows of the late summer tracheids but never more than the sixth row from the outer limit and, occasionally, on a level with the first two or three rows of early spring tracheids. The cells are short and narrow, 65–88 μ being an average length, with a width of 3–5 μ radially and 16 μ tangentially, with all the walls lignified, the end ones being irregular in outline.

In this species the resin cells form a more continuous series longitudinally than in the others, often 10–20 occurring end to end before they are replaced by a wood-tracheid, and often two narrow cells occur side by side, occupying only the space of a normal one. On the lateral walls bordered pits are common with lenticular openings (fig. 27).

Juniperus communis, *Linn.*

This species, although already described, is added for the sake of completeness, as it occurs in the North-West Himalaya, at 5400–14,000 feet elevation, in which region it is said to rarely grow to a height of more than 6–7 feet, often with a thick stem 18–24 feet in girth.

Macroscopic (naked eye).

The wood is very light reddish brown in colour, with 33 rings per inch of radius in my specimen, but Gamble gives 35–50 as being general. The rings are very variable in width, some being fairly wide and others narrow. The medullary rays are just visible.

Microscopic (tracheids).

In transverse sections the spring wood gradually merges into the summer, but occasionally the transition is more sudden, sometimes the latter occupying nearly half the entire ring but in other cases little more than a quarter. The length of the tracheids is shorter in this species than in the others, 1–2 mm. being an average length, with width of lumen and thickness of wall as follows :—

	Width of lumen.		Thickness of wall.	
	Radial.	Tangential.	Radial.	Tangential.
Spring wood	18·2 μ	8·6 μ	1·9 μ	1·9 μ
Summer wood	3·8 μ	3·6 μ	2·8 μ	2·8 μ

The ends of the tracheids are more or less rounded off, with occasional flattened ones opposed to each other, with a bordered pit between the two. Usually, however, the tracheids run straight. The bordered pits on the radial walls of the spring and summer wood are arranged in a single row, and are not so numerous or so near together as in the other species ; and where

Sanio's rims occur very rarely they stretch completely across the tracheids, but occur just above and below the pit-area. On the tangential walls of the summer wood the pits are more scattered, with openings more lens-shaped than those on the radial walls of either the spring or summer tracheids (figs. 28, 29, 30). Occasionally very short tracheids occur with pits on all their walls. Sanio's bars are numerous.

Medullary Rays.

The rays are fairly numerous, occurring at a distance of 1–8, occasionally 10 tracheids away from each other tangentially. They are mostly uniseriate (occasionally biseriate), 1–20 cells high (figs. 31, 32), made up entirely of thick-walled parenchyma, with a length equal to 3–4 spring tracheids and 2–3 summer tracheids. The end-walls are transverse or oblique and coarsely pitted, but where the rays are only one cell high the cells often dovetail into each other, the end-wall of one cell overlapping that of the next.

All the cells have simple pits on the upper and lower walls and 1–4 bordered pits per wood-tracheid on the lateral walls (mostly one), some being arranged in a single radial row and others in two, with occasionally three pits, one above the other, per wood-tracheid in the summer-wood area (figs. 33, 34). The bordered pits are round with openings lens-shaped and never extending beyond the border. The rays are resinous throughout.

Resin Cells.

The resin cells are numerous, occurring in a zone between the middle of the annual ring to a limit of 15–25 tracheids from the outer limit of the year's growth. Their length is 125–200 μ with a width of 12–15 μ, and rarely more than one cell occurs in each radial row of tracheids. Bordered pits with lens-shaped openings occur on the lateral walls.

The chief points of interest brought out in the wood of the Indian Junipers are :—

1. The shortness of the tracheids of all species.
2. The resinous nature of the medullary rays.
3. The distribution of the resin cells in the annual ring.
4. The nature of the rims above and below the pit-areas (Sanio's rims), these being shown to agree with those of the East Indian Pines in being pectic and not cellulosic.

The material was supplied by the Imperial Economist of Forestry, Dehra Dun, India, to Prof. Groom of the Imperial College, and was obtained from the areas stated below :—

Juniperus Wallichiana, specimen came from Sikkim and supplied by the Divisional Forest Officer, Darjeeling.

Juniperus macropoda came from Baluchistan.
Juniperus recurva: area not exactly known but probably from the inner Himalayas in the Punjab.

I wish to thank the Director of the Imperial Economist School of Forestry, Dehra Dun, for the information as to areas.

In conclusion, I beg to thank Professor Groom, of the Imperial College of Science and Technology, who suggested the work, for his help and criticism during the progress of the investigation.

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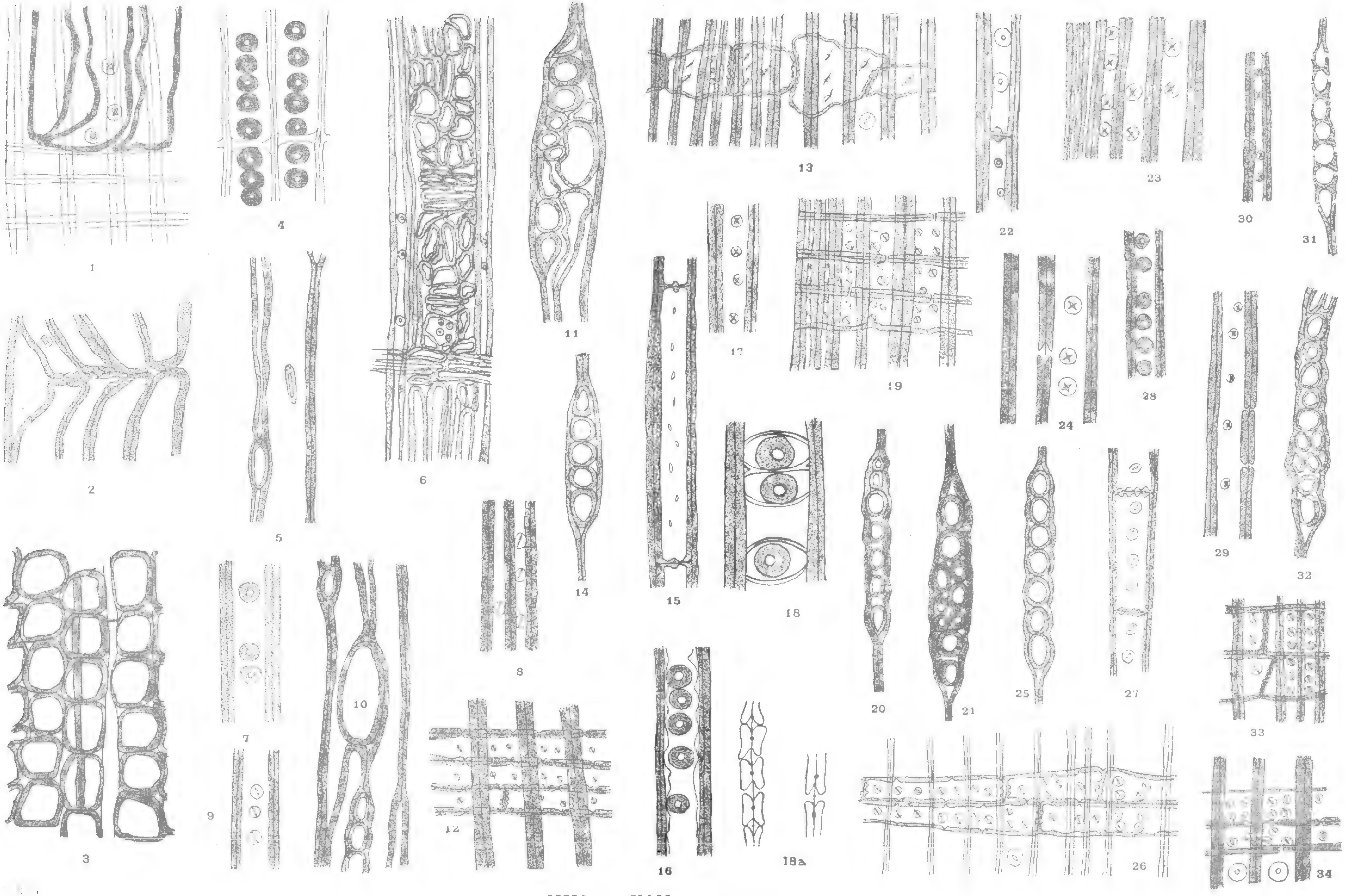
EXPLANATION OF PLATE 1.

Fig. 1. *Juniperus recurva.* Ends of tracheids bending along medullary ray. × 312.
Fig. 2. „ „ End-walls of twisted tracheids with bordered pits on cross-wall. × 312.
Fig. 3. *Juniperus macropoda.* Transverse section of spring wood showing Sanio's bars crossing tracheids. × 312.
Fig. 4. „ „ Sanio's bars running radially (radial section). × 312.
Fig. 5. „ „ Sanio's bars cut tangentially. × 312.
Fig. 6. *Juniperus Wallichiana.* Radial section of a resin cyst probably due to a pathological condition. × 90.
Fig. 7. *Juniperus recurva.* Bordered pits on radial walls of spring wood. × 312.
Fig. 8. „ „ Pits on radial walls of summer wood. × 312.
Fig. 9. „ „ Pits on tangential walls of summer wood. × 312.
Fig. 10. „ „ Large oval area cut tangential owing to tracheids twisting about so much. × 312.
Fig. 11. „ „ Medullary ray-cells pushed out of shape by end of tracheid pushing its way on the side of the ray. × 312.
Fig. 12. „ „ Radial view of medullary ray-cells in spring wood to show pitting and end-walls. × 312.
Fig. 13. „ „ Radial view of medullary ray in summer wood to show shortening of cells and pitting. × 312.



HIMALAYAN JUNIPERS.

Grout, photo sc.

Fig. 14. *Juniperus recurva.* Tangential sections of medullary ray to show shape of cells. × 312.

Fig. 15. ,, ,, Resin cell to show simple pits and end-walls with local thickening. × 312.

Fig. 16. *Juniperus Wallichiana.* Spring-tracheid radial walls showing shape of pits. × 312.

Fig. 17. ,, ,, Pitting of tangential walls of summer-wood tracheids. × 312.

Fig. 18. ,, ,, Part of a spring tracheid to show Sanio's rims × 520.

Fig. 18 *a*. ,, ,, Tangential view of spring tracheid to show Sanio's rims. × 520.

Fig. 19. ,, ,, Radial view of medullary ray in spring and summer wood to show pitting on walls. × 312.

Fig. 20. ,, ,, Tangential view of uniseriate ray to show shape of cells and occurrence of intercellular spaces between them. × 312.

Fig. 21. ,, ,, Tangential section of biseriate ray. × 312.

Fig. 22. ,, ,, Part of resin cell to show bordered pitting. × 520.

Fig. 23. *Juniperus macropoda.* Tracheids of early summer wood, radial section. × 312.

Fig. 24. ,, ,, Pits on tangential walls of late spring wood. × 312.

Fig. 25. ,, ,, Tangential section of uniseriate ray to show shape of cell. × 312.

Fig. 26. ,, ,, Radial view of medullary ray-cells to show pitting of walls. × 312.

Fig. 27. ,, ,, Tangential section of resin cell showing length of pitting and end-walls. × 312.

Fig. 28. *Juniperus communis.* Part of a spring-wood tracheid to show shape of pits on radial walls. × 312.

Fig. 29. ,, ,, Pits on tangential walls of early summer-wood tracheid. × 312.

Fig. 30. ,, ,, Part of summer-wood tracheid to show pitting. × 312.

Fig. 31. ,, ,, Tangential section of a uniseriate medullary ray. × 312.

Fig. 32. ,, ,, Tangential section of part of a medullary ray to show variation of number of cells across. × 312.

Figs. 33 & 34. ,, ,, Radial view of medullary ray in spring wood to show pitting of the walls. × 312.

A Contribution to the Flora of Fiji. By W. B. Turrill. (Communicated by Dr. Otto Stapf, F.R.S., Sec.L.S.)

[Read 2nd April, 1914.]

Since the publication of Seemann's 'Flora Vitiensis' (1865–1873), the only important works dealing with the flora of the Fiji Islands are Horne's 'A Year in Fiji,' and Miss Gibbs's paper "The Montane Flora of Fiji," published in Journ. Linn. Soc., Bot. vol. xxxix. (1909). The present paper deals with part of the interesting collection made by Sir Everard im Thurn, K.C.M.G., in Fiji during the years 1905–1907, namely the Phanerogams excluding the Orchidaceæ, which latter are still under examination. The former consist of 72 species, and of these 24 are described here for the first time. That one-third of the plants are new to science is partly explained by the fact that comparatively little of the interior of Fiji has been botanically explored. Seemann's journeys were restricted to the coastal districts, except for one journey through the mountain region of Namosi. Horne's collections have been very imperfectly worked out and, indeed, many of his specimens are so incomplete and badly preserved as to be practically useless. Miss Gibbs spent three months at Nandarivatu and thoroughly explored only a limited area round that centre. Sir Everard im Thurn had the advantage of being resident in the islands for several years and of visiting a number of localities at several seasons. The majority of the new species come from the Nandarivatu district and Kandavu.

The relatively large number of Rubiaceæ and the absence of Leguminosæ, Compositæ (excepting introduced weeds), and Glumaceæ are peculiarities of the collection, and must not be taken as in any way indicating the proportion of the Orders to the Flora as a whole. The collection is too small for any conclusions on this subject to be drawn from it. It is interesting to note that about one in every seven of the Dicotyledons (excluding those with truly unisexual flowers) shows various stages in the reduction of either the andrœcium or gynæceum. Sometimes, as in *Calophyllum vitiense*, several states are found on the same plant, but more often, as in *Symplocos leptophylla* and the two species of *Litsea*, all the flowers on the same specimen show a similar stage of reduction of either the male or female organs.

The most interesting of the facts disclosed by the collection are undoubtedly those connected with geographical distribution. In the first place mention must be made of *Kermadecia vitiensis*, a new species of a genus hitherto only known to contain three species, all of which are endemic to New Caledonia. It is the first Proteacea to be recorded from Fiji, and moreover, indicates an eastern extension of the known distribution of the order. *Embelia gracilis* is the first member of this Indo-Malayan and African genus to be found in

the islands, though one species is known from Hawaii. *Geisois Imthurnii* is a distinct member of a small genus of eight species, one of which is Australian and the remainder are Polynesian. One new genus has been described and called *Pareugenia*. It differs from *Eugenia* in having the filaments united irregularly into a varying number of bundles.

Sir Everard's field-notes contain much valuable and interesting information and have been incorporated in their entirety.

In giving the distribution of the species only those countries are quoted from which specimens, contained in the Kew or British Museum Herbaria, have been seen, and as far as possible verified by the writer. The classification followed is that of Bentham and Hooker's 'Genera Plantarum,' while under each genus the species are arranged alphabetically. It has been thought advisable to include those few plants which, owing to the condition of the material, it has only been possible to identify generically. Plants not previously recorded from Fiji are marked with an asterisk.

In conclusion I must acknowledge with many thanks the kind help and advice received from Dr. Stapf, F.R.S., and Mr. W. G. Craib, M.A.

RANUNCULACEÆ.

Clematis Pickeringii, *A. Gray, Bot. U.S. Expl. Exp.* p. 1 ; *Seemann, Fl. Vit.* p. 3.

Near Suva, growing commonly on bushes along the road to Colo-i-Suva, *i. e.* nearly at sea-level, but also at the edge of the forest near Nandarivatu, about 750 m., in flower May 20th, 1907, *im Thurn*, 351.

Distr. Fiji (Viti Levu, Ovalau, Vanua Levu).

ANONACEÆ.

Cananga odorata, *Hook. f. et Thoms., Fl. Ind.* vol. i. p. 130 ; *Seemann, Fl. Vit.* p. 4.

Nandarivatu, about a mile along the road to Ba, in flower Nov. 26th, 1906, *im Thurn*, 288.

Distr. India, Indo-China, Malaya, Polynesia.

VIOLACEÆ.

Agatea violaris, *A. Gray, Bot. U.S. Expl. Exp.* p. 89, t. 7 ; *Gibbs in Journ. Linn. Soc.* xxxix. (1909) p. 140.

Agation violare, Brongn. in Bull. Soc. Bot. Fr. viii. (1861) p. 80.

Nandarivatu, by the "Governor's Seat," in flower and fruit Jan. 31st, 1906, *im Thurn*, 61.

Distr. Fiji (Viti Levu, Taviuni, Moala).

A creeper, with dense masses of small purple flowers. This is one of several creepers of similar habit which mat together the undergrowth at the edge of coppices and round clearings.

The specimens collected by Sir Everard belong to Seemann's var. β.

GUTTIFERÆ.

Calophyllum vitiense, *Turrill*, sp. n. *C. Tacamahaca*, Willd., affine, sed foliorum nervis lateralibus magis distantibus, pedicellis brevioribus, racemis longioribus differt.

Arbor, ramis teretibus vel subquadrangularibus glabris. *Folia* lanceolata, apice obtusa vel breviter et obtuse acuminata, basi cuneata, usque ad 17 cm. longa, 5·5 cm. lata, subcoriacea, glabra, integra, nervis lateralibus parallelis numerosis 1 mm. inter se distantibus; petioli usque ad 1·5 cm. longi. *Inflorescentia* glabra, terminalis vel axillaris, racemis lateralibus cum pedunculo communi usque ad 10 cm. longis; pedicelli circiter 5 mm. longi; bracteæ minutæ. *Sepala* 4, late obovata, 1·5 cm. longa, 1·3 cm. lata *Petala* 4, obovata, 1·5 cm. longa, 1 cm. lata. *Stamina* indefinita, filamentis ima basi obsolete connatis 3 mm. longis, antheris 1 mm. longis. *Ovarium* ovoideum, 3 mm. altum, 2·5 mm. diametro; stylus (in floribus hermaphroditis) 5 mm. longus, stigmate peltato.—*C. spectabile*, Seem. (Fl. Vit. p. 12), non Willd.

Viti Levu, *Seemann*, 47; Nandarivatu, at the edge of the forest round "the farm," some three miles along the road to Suva, in flower Dec. 2nd, 1906, *im Thurn*, 297.

The native name is "Damanu dilodilo" (ex *Seemann*).

Seemann says that his samples (no. 47) came from a tree not in flower, and that Asa Gray identified them with flowering specimens, which he considered to be *C. spectabile*, Willd., obtained by the United States Exploring Expedition in Fiji. I have not seen the latter, but *Seemann*, 47, is certainly conspecific with *im Thurn*, 297, and the species is not *C. spectabile*, Willd., which has smaller flowers with no petals, and very much smaller, more compact, axillary inflorescences. It is also easily distinguished from the widely-spread *C. Inophyllum*, Linn., by the shape of the leaves and the shortly pedicellate flowers.

TERNSTRŒMIACEÆ.

Saurauia rubicunda, *Seemann, Fl. Vit.* p. 14; *Gibbs in Journ. Linn. Soc.* xxxix. (1909) p. 141.

Nandarivatu, in flower Nov. 19th, 1906, *im Thurn*, 256; Navai, *i. e.* at the foot of Mt. Victoria on the north side, in flower Dec. 5th, 1906, *im Thurn*, 319.

Distr. Fiji (Viti Levu, Vanua Levu, Ovalau, Ngau, Tamavuci).

A tree with large pink flowers.

TILIACEÆ.

*GREWIA VITIENSIS, *Turrill*, sp. n. *G. asperæ*, Roxb., affinis, sed alabastris brevioribus ovoideis, sepalis latioribus distinguitur.

Arbor parva, 6 m. alta (ex *im Thurn*), ramis teretibus primo dense patule hirsutis mox glabrescentibus. *Folia* elliptico-ovata, apice acuta vel breviter et obtuse acuminata, basi rotundata vel plus minusve cordata, laminis usque ad 10 cm. longis et 7 cm. latis, margine leviter et irregulariter crenata, pagina superiore adpresse pubescentia, inferiore molliter pubescentia, nervis lateralibus utrinque 6–7 cum costa supra subprominentibus hirsutis infra prominentibus dense hirsutis; petioli usque ad 1·5 cm. longi, dense patule hirsutis. *Inflorescentiæ* 2–5-floræ, terminales vel axillares. *Alabastra* ovoidea, ante anthesin 7 mm. alta, 6 mm. diametro. *Sepala* 5, elliptico-oblanceolata, apice acuta, 1·1 cm. longa, 0·4 cm. lata, extra dense stellato-tomentosa, intus fere glabra. *Petala* oblongo-lanceolata, apice acuta, 5 mm. longa, 1·3 mm. lata, ad partem trientem e basi linea transversa densa pilorum barbata, supra lineam omnino glabra, infra lineam puberula, e linea basin versus conspicue ciliata. *Stamina* indefinita. *Androgynophorium* circiter 1 mm. altum, apice ciliatum. *Stamina* ∞, filamentis filiformibus circiter 4 mm. longis leviter pubescentibus, antheris 0·75 mm. longis. *Ovarium* late ovoideum, 2 mm. altum, 2·5 mm. diametro, dense hirsutum; stylus cum ramis 2 mm. longus, hirsutus. *Fructus* circiter 1·5 cm. altus et 1·5 cm. diametro, subinteger, pilis brevibus stellatis tectus.

Nandarivatu, along an old Matekula warpath, in flower and fruit Nov. 24th, 1906, *im Thurn*, 279.

A small tree, 20 feet high, with *Mespilus*-like flowers.

RHAMNACEÆ.

ALPHITONIA EXCELSA, *Reiss. ex Endl. Gen.* 1098; *Gibbs in Journ. Linn. Soc.* xxxix. (1909) p. 143.

Nandarivatu, by the "Governor's Seat," a shrub in flower Jan. 31st, 1906, *im Thurn*, 57.

Distr. Fiji (Viti Levu, Totoya), Tahiti, New Caledonia, Tonga Islands, Samoa, Rarotonga, E. Australia, Malaya.

The species in the wide sense, with the distribution given above, is very polymorphic and the Nandarivatu plant is one of the numerous forms. It has smaller, more obtuse leaves with closer venation than most specimens, and the inflorescence is terminal, much branched, and more corymb-like.

SAPINDACEÆ.

*CUPANIOPSIS sp.?

A specimen collected in fruit only, near Nandarivatu, a mile or two along the road to Suva, on Nov. 22nd, 1906, *im Thurn*, 268, is probably an undescribed species of this genus, but without flowers it is impossible to be certain.

ANACARDIACEÆ.

RHUS SIMARUBÆFOLIA, *A. Gray, Bot. U.S. Expl. Exp.* p. 367, t. 44; *Seemann, Fl. Vit.* p. 49; *Gibbs in Journ. Linn. Soc.* xxxix. (1909) p. 144.

Nandarivatu, in flower Nov. 27th, 1906, *im Thurn*, 293.

Distr. Fiji (Viti Levu, Vanua Levu).

A common tree with *Spiræa*-like flowers and ash-like leaves.

Sir Everard's specimens differ from the type in having the leaves and the axes of the inflorescence distinctly pubescent. The inflorescences are as long as the leaves. The leaflets are elliptical-oblong in shape and have a rounded or emarginate apex. The structure of the flowers (disc, etc.) is exactly similar to that in the type.

CORIARIACEÆ.

CORIARIA RUSCIFOLIA, *Linn. Sp. Pl.* 1037; *Horne, 'A Year in Fiji,'* p. 259.

Nandarivatu, down in the ravine into which the second fall below the bathing-pool drops, in flower Feb. 3rd, 1906, *im Thurn*, 68.

Distr. Fiji (Viti Levu), Samoa, Banks Island, Kermadec Isles, New Zealand, Chile, Peru.

SAXIFRAGACEÆ.

*GEISSOIS IMTHURNII, *Turrill*, sp. n. *G. ternatæ*, A. Gray, affinis, sed foliolis fere sessilibus pagina utraque pubescentibus facile distinguenda.

Arbor, ramis teretibus junioribus dense adpresse pubescentibus. *Folia* trifoliolata, petiolo usque ad 2 cm. longo suffulta; foliola fere sessilia, obovata, apice rotundata, basi subacuta vel subrotundata, usque ad 9 cm. longa, 5 cm. lata, subcoriacea, integra, nervis lateralibus utrinque 12–15, pagina utraque pubescentia. *Inflorescentia* leviter pubescens, racemis lateralibus solitariis vel 2–3-aggregatis circiter 4·5 cm. longis usque ad 15-floris, pedunculo communi usque ad 1·5 cm. longo suffultis; pedicelli circiter 5 mm. longi; bracteæ 1·5 mm. latæ. *Sepala* 4, ovato-lanceolata vel oblongo-lanceolata, subacuta, 6 mm. longa, 2·5 mm. lata, coriacea, pagina utraque minute pubescentia. *Petala* 0. *Stamina* 7 (an semper?), filamentis 1·6 cm. longis, antheris 1·25 mm. longis. *Discus* annularis, crenatus, 1 mm. altus. *Ovarium*

oblongo-conicum, 3 mm. altum, 1·25 mm. diametro, glabrum; styli duo, 9 mm. longi.

Nandarivatu, in flower March 7th, 1906, *im Thurn*, 137. It is this tree on which the little crimson paraquets are fond of feeding. The native name is "common vunga."

In a note on *Geissois ternata*, A. Gray, Seemann (Fl. Vit. p. 109) says "the native name I had for this is 'Vuga,' identical with that of *Metrosideros polymorpha*, but either in the one case or the other I must have been misinformed."

Sir Everard im Thurn's notes taken in conjunction with Seemann's statement, seem to show that the name 'vunga' is used for at least two species of *Geissois*, and also, with the addition of qualifying adjectives, for *Metrosideros polymorpha* and *Agapetes vitiensis*.

WEINMANNIA RHODOGYNE, *Gibbs in Journ. Linn. Soc.* xxxix. (1909) p. 145.

Nandarivatu, common everywhere thereabouts, in flower Feb. 4th, 1906, *im Thurn*, 73.

Distr. Fiji (Viti Levu).

The flowers are yellow orange in colour.

The axes of the racemes in both the type and Sir Everard's specimens are puberulous.

MYRTACEÆ.

METROSIDEROS VILLOSA, *Sm. in Trans. Linn. Soc.* vol. iii. (1797) p. 268; *Gibbs, l. c.* p. 146. *Metrosideros polymorpha*, Gaud., Bot. Voy. Freyc. pp. 99 et 482, tt. 108, 109; Seemann, Fl. Vit. p. 83.

Nandarivatu, common, in flower, *im Thurn*, 129.

The flowers of this specimen are yellow but red-flowered plants are common.

Distr. Pacific Islands generally.

The native name is "Orange Vunga" (ex *im Thurn*).

The specimens collected by Sir Everard belong to Seemann's var. β and to Gaudichaud's var. δ. The species, however, varies so much in the shape and size of its leaves, in the pubescence of the inflorescence and in the colour of the flowers, that it is useless to found varieties on these characters.

*EUGENIA (SYZYGIUM) DIFFUSA, *Turrill*, sp. n. *E. nivulari*, Seemann, affinis, sed floribus majoribus, foliorum nervis lateralibus paucioribus et magis distantibus facile distinguenda.

Arbor, ramis teretibus glabris. *Folia* opposita, lanceolata vel elliptico-lanceolata, apice acuminata, basi acuta, usque ad 10 cm. longa et 3·5 cm. lata, chartacea, utrinque glabra, integra, nervis lateralibus utrinque circiter

20; petioli 3–5 mm. longi, glabri. *Inflorescentia* laxa, ramosa, glabra, paniculis usque ad 20-floris, pedunculis 6–9 cm. longis, pedicellis circiter 0·75 cm. longis; bracteæ bracteolæque minutissimæ. *Calycis* limbus in marginem truncatam vix productus. *Petala* 4, suborbicularia, inter se subæqualia, circiter 2 mm. diametro. *Stamina* libera, filamentis 14 mm. longis glabris. *Receptaculum* pyriforme, glabrum, 1 cm. altum, 4 mm. diametro. *Ovarium* 2-loculare, loculis multiovulatis; stylus 1·2 cm. longus, glaber.

Kandavu, Mt. Washington (Nabukelevu), 810 m., in flower April 4th, 1905, *im Thurn*, F. 9.

*EUGENIA (JAMBOSA) VITIENSIS, *Turrill*, sp. n. *E. gracilipedi*, A. Gray, affinis, sed foliis basi non cordatis, pedicellis brevioribus et robustioribus, floribus majoribus recedit.

Arbor, ramis quadrangularibus vel teretibus glabris. *Folia* elliptico-lanceolata, acuminata, basi rotundata, usque ad 18 cm. longa et 6·5 cm. lata, utrinque glabra, integra, nervis secundariis circiter 12; petioli circiter 2 mm. longi, glabri. *Inflorescentia* glabra, racemis terminalibus trifloris, pedunculis 5 cm. longis, pedicellis 2 cm. longis; bracteæ et bracteolæ minutæ, caducæ. *Calyx* distincte 4-lobatus, lobis rotundatis inter se æqualibus. *Petala* 4, suborbicularia, 1·2 mm. longa, 1·3 mm. lata, glabra. *Stamina* libera, filamentis 16 mm. longis. *Receptaculum* glabrum, turbinatum, 1 cm. altum, 1·3 cm. diametro. *Ovarium* 2-loculare, loculis ∞-ovulatis; stylus 3·5 cm. longus.

Kandavu, on the way up to Mt. Washington (Nabukelevu), in flower March 4th, 1905, *im Thurn*, 9.

PAREUGENIA, *Turrill* [Myrtaceæ–Myrteæ]; genus novum *Eugeniæ*, Linn., affine, filamentis in phalanges 8–16 dispositis distinctum.

Petala 5, in calyptram connata. *Stamina* numerosa, in phalanges plures distincte connata, superne ad partem tertiam libera, antheris bilocularibus basifixis vel leviter versatilibus. *Ovarium* biloculare, ovulis in loculis numerosis pluriseriatis, placentis prominentibus axilibus.—*Arbor*, foliis oppositis.

*PAREUGENIA IMTHURNII, *Turrill*, species unica.

Arbor parva (ex *im Thurn*), ramis teretibus glabris cortice pallido obtectis. *Folia* elliptico-ovata vel oblongo-ovata, apice leviter obtuse acuminata, rotundata vel retusa, basi acuta vel subcuneata, usque ad 9 cm. longa et 4·8 cm. lata, coriacea, pagina utraque glabra, integra, nervis lateralibus parallelis utrinque circiter 20; petioli usque ad 1·5 cm. longi, glabri. *Inflorescentia* terminalis, ad 20-flora, e racemis 3–5-floris oppositis demum corymbosim dispositis constituta; racemi inferiores pedunculo terete circiter

2 cm. longo suffulti; pedicelli 0·5–1 cm. longi, robustiores, glabri; bracteæ oppositæ, persistentes, suborbiculares, apice rotundatæ, 2 mm. longæ, 1·5 mm. latæ, sessiles, glabræ; bracteolæ 2, oppositæ, vel 4, oppositæ et decussatæ, bracteis similes. *Calyx* indistincte 4-lobatus, lobis apice rotundatis glabris. *Petala* 5, in calyptram connata, late orbicularia, apice rotundata, circiter 5 mm. longa et 7 mm. lata, coriacea, glabra. *Stamina* numerosa, polyadelpha, glabra, filamentis (parte connata inclusa) usque ad 1·2 cm. longis, antheris 0·75 mm. longis. *Receptaculum* turbinatum, 5–6 mm. altum, 5–6 mm. diametro, glabrum. *Ovarium* biloculare, ovulis in quoque loculo circiter 12; stylus cylindricus, 6 mm. longus, glaber, stigmate subcapitato.

Nandarivatu, "Single-tree Hill," in flower Nov. 21st, 1906, *im Thurn*, 262.

MELASTOMATACEÆ.

MELASTOMA DENTICULATUM, *Labill., Sert. Austr. Caled.* p. 65, t. 64; *Seemann, Fl. Vit.* p. 89; *Gibbs in Journ. Linn. Soc.* xxxix. (1909) p. 147. *Melastoma vitiense*, Naudin, Melastomac. p. 141; A. Gray, Bot. U.S. Expl. Exp. p. 601.

Navai, in flower March 28th, 1906, *im Thurn*, 199.

Distr. Fiji (Viti Levu, Vanua Levu, Ovalau, Totoya) and Pacific Islands generally.

This was gathered because of its few large white flowers which seemed to distinguish it from the common form, which is a troublesome weed in the coastal cattle pastures.

MEDINILLA LONGICYMOSA, *Gibbs, l. c.* p. 147, pl. 14.

Nandarivatu, side of wood by first mile-post on road to Ba, in flower Nov. 25th, 1906, *im Thurn*, 284.

Distr. Fiji (Viti Levu).

A tall tree, 40 feet high, with white flowers sheathed in two deep pink bracts.

MEDINILLA RHODOCHLÆNA, *A. Gray, Bot. U.S. Expl. Exp.* p. 600; *Seemann, Fl. Vit.* p. 88; *Gibbs, l. c.* p. 147.

Nandarivatu, *im Thurn*, sine numero.

Distr. Fiji (Viti Levu, Ovalau), Samoa.

MEDINILLA spp.

Two specimens from Nandarivatu without numbers, undoubtedly belong to this genus, but the material is insufficient for specific determination.

SAMYDACEÆ.

*Homalium nitens, *Turrill*, sp. n. *H. vitiensi*, F. Muell., affine, sed foliis minoribus, inflorescentiis gracilioribus, pedicellis longioribus, sepalis petalisque longioribus et angustioribus præcipue differt.

Arbor (ex *im Thurn*), ramis teretibus primo pubescentibus mox glabris, lenticellis longitudinaliter oblongis instructis. *Folia* variabilia elliptico-obovata, ovato-lanceolata vel ovato-elliptica, usque ad 5·5 cm. longa et 3 mm. lata, apice subacuminata, basi acuta, chartacea, glabra, pagina utrinque nitentia, margine integra vel leviter crenata, distincte reticulata, nervis lateralibus utrinque circiter 8; petioli 1 cm. longi, glabri. *Inflorescentia* gracilis, densius pubescens, e paniculis usque ad 18 cm. longis constituta, floribus singulis vel binis, pedicellis circiter 2 mm. longis; bracteæ pubescentes, 2 mm. longæ; bracteolæ minutæ. *Flores* 8-meri (an semper?). *Sepala* linearia, apice acuta, fere 4 mm. longa, circiter 0·25 mm. lata, pubescentia. *Petala* linearia, apice subacuta, 3 mm. longa, circiter 0·3 mm. lata, pubescentia. *Stamina* numerosa, ad quodque petalum 3–4 approximata. *Receptaculum* cylindrico-turbinatum, pubescens, 3 mm. altum, 0·75 mm. diametro. *Ovarium* pubescens, uniloculare, ovulis circiter 12; styli 4, liberi, 1·5 mm. longi, pubescentes; stigmata simplicia, non capitata.

Nandarivatu, along the road to Ba, in flower March 6th, 1906, *im Thurn*, 132.

The upper surface of the leaves often shows numerous circular patches of dead tissue, probably caused by some parasitic fungus.

PASSIFLORACEÆ.

Passiflora vitiensis, *Mast. in Journ. Linn. Soc., Bot.* xvii. (1871) p. 634; *Gibbs in Journ. Linn. Soc.* xxxix. (1909) p. 148. *Disemma vitiensis*, Seemann, Fl. Vit. p. 96.

Nandarivatu, by the second mile-post on the road to Suva, growing freely over bushes under the shade of forest-trees, in flower Nov. 27th, 1906, *im Thurn*, 292.

Distr. Fiji (Viti Levu), Samoa?

A slender creeper, with few leaves and flowers. The leaves, stem, and fruit are remarkably glaucous. The flowers are of a pale terra-cotta colour.

UMBELLIFERÆ.

*Apium leptophyllum, *F. Muell. ex Benth. Fl. Austral.* iii. p. 372.

Nandarivatu, along the roadside down to the landing-place at Tavua, in flower and fruit March 10th, 1906, *im Thurn*, 140.

Distr. Australia, S. America, Tropical Africa, Mascarenes.

An introduced weed?

RUBIACEÆ.

Dolicholobium oblongifolium, *A. Gray in Proc. Amer. Acad.* iv. (1860) p. 309 ; *Seemann, Fl. Vit.* p. 121.

Nandarivatu, in flower Dec. 2nd, 1906, *im Thurn*, 299.

Distr. Fiji (Viti Levu, Vanua Levu).

A tree or tall shrub, 15 feet in height.

Sir Everard's specimens differ slightly from Milne's (quoted by A. Gray in the original description) in having rounded, not acute, bases and somewhat larger flowers.

Ophiorrhiza laxa, *A. Gray, l. c.* p. 312 ; *Seemann, Fl. Vit.* p. 127 ; *Gibbs in Journ. Linn. Soc., Bot.* xxxix. (1909) p. 151.

Nandarivatu, in flower Nov. 20th, 1906, *im Thurn*, 259.

Distr. Fiji (Viti Levu, Ovalau, Ngau).

A small shrub, 3 feet in height, with minute violet flowers.

Seemann (*l. c.*) states that A. Gray considered *O. leptantha* and *O. laxa* to be confluent, and Miss Gibbs endorses this opinion. Judging only from the specimens collected by Sir Everard (259 and 359) the species seem quite distinct, being distinguishable at a glance by the difference in the size of the flowers. Moreover, Sir Everard states that the habits are quite different. The material at Kew is not sufficient to settle the question.

Ophiorrhiza leptantha, *A. Gray, l. c.* ; *Seemann, Fl. Vit.* p. 127.

Suva, in flower July 28th, 1907, *im Thurn*, 359.

Distr. Fiji (Viti Levu).

The flowers are almost pure white when fresh.

Ophiorrhiza peploides, *A. Gray, l. c.* p. 311 ; *Seemann, Fl. Vit.* p. 127.

Nandarivatu, by the bathing-pool, in flower Feb. 4th, 1906, *im Thurn*, 76 ; Navai, in flower March 28th, 1906, *im Thurn*, 202.

Distr. Fiji (Viti Levu, Vanua Levu, Ovalau, Matuku).

A very small shrub, with small starry white flowers, growing in the dense forest.

*Gardenia Hutchinsoniana, *Turrill*, sp. n. *G. taitensi*, DC., affinis, sed foliis longe petiolatis oblongis vel oblongo-oblanceolatis acuminatis, calycis lobis majoribus corollæ tubum superantibus.

Arbor vel frutex, ramis teretibus glabris vel junioribus puberulis levibus. *Folia* opposita vel ramorum apice sæpe solitaria, oblonga vel oblongo-oblanceolata, acuminata, acumine ad 0·75 cm. longo obtuso, basi cuneata, usque ad 12·5 cm. longa (petiolo excluso) et 4·5 cm. lata, membranacea,

omnino glabra, integra, nervis lateralibus utrinque circiter 10–12 pagina utraque prominentibus, nervis transversis inconspicuis; petioli usque ad 2 cm. longi, glabri vel puberuli; stipulæ intrapetiolares plerumque fere ad apicem connatæ sed interdum ima basi tantum connatæ, apice rotundatæ vel truncatæ, 5 mm. longæ, glabræ, margine hyalinæ et sæpe leviter ciliatæ. *Flores* solitarii, terminales, pedicello 1–1·5 cm. longo glabro. *Calyx* 3·5 cm. longus, tubo infundibuliformi glabro, limbo 3-partito, laciniis falcatis glabris valde nervosis, nervis lateralibus e nervo primario angulo satis acuto ortis omnibus demum subparallelis. *Corollæ* tubus infra cylindricus superne ampliatus, 3 cm. longus, ima basi 5 mm. diametro, ad faucem 1 cm. diametro, extra glaber, intra pilorum lineis petalis oppositis instructus; lobi 7–8 oblique ovati, 2·5 cm. longi, 1·5 cm. lati, glabri. *Stamina* 7–8; antheræ sessiles, lineari-oblongæ, apice acutæ, 1·9 cm. longæ. *Receptaculum* cylindricum, 8 mm. longum, glabrum. *Ovarium* uniloculare; stylus (stigmate incluso) 3·2 cm. longus, glaber, stigmate fusiformi 1·2 cm. longo.

Nandarivatu, common at the edge and in the more open parts of the forest, in flower Feb. 26th, 1906, *im Thurn*, 120.

*Ixora bullata, *Turrill,* sp. n. *S. salicifoliæ*, Blume, affinis, sed foliis bullatis apice acutis non caudato-acuminatis, corollæ tubo breviore distincta.

Frutex (?), ramis teretibus glabris. *Folia* lineari-oblonga, apice acuta, basi cordata, usque ad 28·5 cm. longa et 2·5 cm. lata, coriacea, pagina inferiore puberula, superiore glabra, margine integra, revoluta, bullata, nervis omnibus supra impressis infra prominentibus, costa supra canaliculata, nervis lateralibus fere horizontalibus usque ad 40, marginem versus anastomosantibus, sessilia; stipulæ interpetiolares e basi lata acuminatæ, 7 mm. longæ. *Inflorescentia* terminalis, e corymbis trichotome ramosis constituta; pedunculi circiter 2 mm. longi, puberuli; pedicelli circiter 2 mm. longi, puberuli; bracteæ bracteolæque magnitudine variabiles, parvæ, puberulæ, apice acutæ vel acuminatæ. *Receptaculum* turbinatum, 1 mm. altum, 0·75 mm. diametro, puberulum. *Calyx* extra puberulus, intra pubescens, tubo crateriformi 1 mm. longo, lobis 4 ovatis vel oblongis 2 mm. longis 1·5 mm. latis. *Corolla* glaberrima, tubo cylindrico 1·5 cm. longo, 1·25 mm. diametro, lobis 4 oblongis apice subacutis 7 mm. longis 2·5–3 mm. latis. *Stamina* 4, glabra, filamentis 2 mm. longis, antheris lineari-ellipticis 6 mm. longis. *Discus* carnosus, annularis, ovarium coronans. *Ovarium* typice biloculare; stylus (stigmate incluso) 2 cm. longus, pubescens; stigmata distincte bilobatum, 3 mm. longum.

Colo-i-Suva, 90 m., in flower July 28th, 1907, *im Thurn,* 359.

It has white *Bouvardia*-like flowers.

The long, strap-shaped, bullate leaves distinguish this species at a glance from other Polynesian members of the genus.

*CALYCOSIA GLABRA, *Turrill*, sp. n. *C. Milnei*, A. Gray, affinis, sed calycibus majoribus, corollis longioribus facile distinguenda.

Frutex (ex *im Thurn*), ramis teretibus glabris, nodis ramulorum apices versus 1–1·5 cm. inter se distantibus. *Folia* elliptico-lanceolata, apice obtusa, basi acuta, usque ad 16 cm. longa (petiolo excluso) et 6·5 cm. lata, membranacea, glaberrima, integra, costa supra anguste canaliculata, nervis lateralibus utrinque 9–13 pagina inferiore prominentibus superiore subprominentibus marginem versus curvatis, nervis transversis inconspicuis; petioli plerumque circiter 2 cm. longi, rarius usque ad 4·5 cm. longi, glabri; stipulæ intrapetiolares, in vaginam connatæ, 2 mm. longæ, truncatæ. *Inflorescentiæ* terminales, laxæ, e paniculis vel racemis radiatis constitutæ; pedunculi circiter 5·5 cm. longi, glabri; pedicelli usque ad 1 cm. longi, glabri; bracteæ minutissimæ. Calycis tubus cylindricus, 1 cm. longus, medio 2·5 mm. diametro, superne leviter ampliatus; limbus glaber, patens, ampliatus, usque ad 2·5 cm. diametro, 5-lobatus, lobis rotundis. *Corollæ* tubus cylindricus, 3·5 cm. longus, medio 2 mm. diametro, superne leviter ampliatus, extra glaber, intra leviter pubescens; limbus 5-lobatus, lobis lineari-oblongis obtusis 5·5 mm. longis 2 mm. latis glabris. *Stamina* linearia, filamentis 1·5 cm. longis pubescentibus, antheris 4 mm. longis. *Receptaculum* turbinatum, 3·5 mm. altum, 2·5 mm. diametro, glabrum. *Discus* ovarium coronans, hemisphericus. *Stylus* glaber.

Kandavu, on the way up Mt. Washington (Nabukelevu), in flower March 5th, 1905, *im Thurn*, F. 10.

A shrub with showy white flowers.

CALYCOSIA PUBIFLORA, *A. Gray in Proc. Amer. Acad.* iv. (1860) p. 306; *Seemann, Fl. Vit.* p. 133.

Nandarivatu, by the road through "the farm" to Suva, with young flowers Dec. 2nd, 1906, *im Thurn*, 298.

Distr. Fiji (Viti Levu, Taviuni).

A tree or tall shrub, 6 m. high.

The flowers are much younger and the inflorescences much more condensed than in the type specimens at Kew. The corollas are only 2 to 3 mm. in length and quite enclosed in the calyx. The petioles are somewhat longer than in the type, but the venation, texture, and shape of the blades agree exactly.

PSYCHOTRIA EFFUSA, *Turrill.* *P. sulphureæ*, Seemann, affinis, sed foliis acuminatis, pedicellis longioribus, corollæ tubo breviore differt.

Arbor parva (ex *im Thurn*) vel liana (ex *Gibbs*); rami teretes, glabri. *Folia* oblongo-lanceolata, acuminata, basi cuneata, usque ad 10 cm. longa (petiolo excluso), 4 cm. lata, chartacea, glaberrima, integra, costa supra

canaliculata infra prominente, nervis lateralibus 12–15 supra leviter impressis infra prominentibus marginem versus anastomosantibus; petioli usque ad 2 cm. longi, canaliculati ; stipulæ connatæ. *Paniculæ* ramosissimæ, divaricatæ, minute puberulæ ; bracteæ 1–2 mm. longæ, acutæ ; bracteolæ minutissimæ ; pedicelli 3 mm. longi. *Receptaculum* conicum, 1–1·5 mm. longum, minute puberulum. *Calyx* breviter cupulatus, indistincte 5-lobatus, 0·5 mm. longus, puberulus. *Corolla* infundibuliformis, tubo 4–5 mm. longo extra puberulo intra glabro ; lobi 5, oblongi, 2–5 mm. longi, 1 mm. lati, extra minute et dense puberuli, intra glabri. *Stamina* 5, filamentis corollæ tubo 3 mm. supra ejus basem affixis inde inferne tubo adnatis ad imam basem decurrentibus ; pars libera circiter 2 mm. longa ; antheræ exsertæ, 1·25 mm longæ, glabræ. *Discus* conicus, 0·5 mm. altus. *Ovarium* typice 2-loculare, stylus 4 mm. longus (stigmate incluso), glaber, bifidus ; stigmata 1 mm. longa.—*Psychotria sulphurea*, Gibbs in Journ. Linn. Soc. xxxix. p. 152, non Seemann.

Nandarivatu, *Gibbs*, 542 ; in flower Nov. 24th, 1906, *im Thurn*, 281.

Psychotria Gibbsiæ, *S. Moore ex Gibbs in Journ. Linn. Soc., Bot.* xxxix. (1909) p. 152.

Nandarivatu, in flower Nov. 22nd, 1906, *im Thurn*, 267.

Distr. Fiji (Viti Levu).

A small tree, 6 m. high.

*Psychotria Imthurnii, *Turrill*, sp. n. *H. Forsterianæ*, A. Gray, affinis, sed inflorescentia dense ferrugineo-pubescente distinguenda.

Frutex (ex *im Thurn*), ramis glabris, internodiis compressis. *Folia* elliptico-lanceolata, apice obtusa, basi acuta, usque ad 18·5 cm. longa et 6·8 cm. lata, membranacea, glaberrima, siccitate supra flavido-viridia, infra grisea vel fere argentea, integra, costa supra prominula infra prominente, nervis lateralibus utrinque circiter 15 supra leviter canaliculata infra prominentibus marginen versus sursum curvatis; petioli 3–4 cm. longi, glabri ; stipulæ scariosæ in vaginam connatæ, 2·5 cm. longæ. *Inflorescentia* terminalis, multiflora, circiter 3 cm. longa et 3 cm. diametro, ferrugineo-pubescens ; pedicelli usque ad 2 mm. longi, ferrugineo-pubescentes ; bracteæ bracteolæque minutissimæ. *Calyx* urceolatus, 3 mm. longus, 2·5 mm. diametro, 5-dentatus, extra dense pubescens, intra glaber. *Receptaculum* turbinatum, 1·5 mm. longum, 1 mm. diametro, dense pubescens. *Corolla* expansa non visa, probabiliter parva. *Alabastra* obovoidea, obtusa, 4 mm. longa, 2·5 mm. diametro. *Ovarium* typice biloculare.

Nandarivatu, in bud Feb. 13th, 1906, *im Thurn*, 106.

*Psychotria minor, *Turrill*, sp. n. *P. serpenti*, Linn., affinis, sed corolla longiore ad faucem non barbata distinguitur.

Frutex parvus, ramis teretibus bifacialiter sulcatis glabris. *Folia* ovata vel obovata, apice obtusa, basi cuneata, in petiolum angustata, circiter 2·5 cm. longa et 1·5 cm. lata, subcoriacea, glaberrima, integra, costa cum nervis supra indistinctis leviter impressis, infra subprominentibus, nervis lateralibus marginem versus sursum curvatis, nervis transversis inconspicuis ; petioli circiter 3 mm. longi, glabri ; stipulæ intrapetiolares in annulum connatæ. *Inflorescentia* terminalis, laxa, multiflora, usque ad 4 cm. longa et 3·5 cm. diametro, glabra ; pedicelli 2 mm. longi, glabri ; bracteæ bracteolæque connatæ, truncatæ, 0·5–1 mm. longæ, glabræ. *Receptaculum* conicum, fere 1 mm. longum, glabrum. *Calyx* breviter cupulatus, truncatus vel indistincte 5-dentatus, 0·5 mm. longus, 1·75 mm. diametro, glaber. *Corolla* infundibuliformis, extra farinosa ; tubus cylindricus, superne leviter ampliatus, 3·5 mm. longus, basi 1·25 mm. diametro, intra ad faucem glaber, ad staminum insertionem pubescens ; lobi 4, oblongi, apice obtusi, 3 mm. longi, 1·5 mm. lati, supra glabri. *Stamina* 4, 2·5 mm. supra tubi basem inserta, filamentis 1·5 mm. longis, antheris 1 mm. longis. *Discus* hemisphericus, 0·5 mm. altus. *Ovarium* typice biloculare, stylo glabro.

Top of Mount Victoria, 1500 m., in flower May 1st, 1905, *im Thurn*, F. 21.

*PSYCHOTRIA SOLANOIDES, *Turrill*, sp. n. *P. tetragonæ*, Seemann, affinis, sed foliis basi subcordatis, baccis majoribus recedit.

Frutex (ex *im Thurn*), ramis teretibus glabris. *Folia* ramorum apicem versus aggregata, obovato-elliptica, apice subobtuse acuminata, basi subcordata, usque ad 9 cm. longa et 2·8 cm. lata, chartacea, supra glabra, infra hirsuta, integra, nervis lateralibus utrinque circiter 12 marginem versus anastomosantibus cum costa pagina utraque leviter prominentibus, nervis transversis indistinctis ; petioli 5–7 mm. longi, hirsuti. *Flores* 2–5 aggregati, terminales, fere sessiles. *Receptaculum* cylindricum, 1·5 mm. longum, 1 mm. diametro, glabrum. *Calyx* cupuliformis, 4 mm. longus, 3 mm. diametro, glaber, 5–6 dentatus. *Corollæ* tubus 1 cm. longus, extra glaber, intra inferne pubescens ; lobi 5–6, 3 mm. longi, 1·5 mm. lati, extra pubescentes, intra glabri. *Stamina* 5–6, filamentis inferne corollæ tubo adnatis ad imam basem decurrentibus, antheris leviter exsertis 2·5 mm. longis glabris. *Discus* fere sphericus, 1 mm. altus, ovarium coronans. *Ovarium* 2-loculare, ovulis in quoque loculo solitariis basilaribus ; stylus 1·1 cm. longus (stigmate incluso), glaber, bifidus ; stigmata 1 mm. longa. *Bacca* obovoidea, 1·5 mm. longa, 1·3 mm. diametro, aurantiaca (ex *im Thurn*). *Semina* 2, ambitu obovoidea, sectione transversa acute triangularia, facie majore plana, duabus minoribus concava, summo apice excavata, 6 mm. longa, 5 mm. diametro.

Nandarivatu, in flower and fruit Nov. 19th, 1906, *im Thurn*, 257.

A shrub with very few minute white flowers and orange *Solanum*-like fruits.

Some doubt was felt at first whether this very distinct species should be placed in the genus *Psychotria* or in the genus *Cephaëlis*. These two genera are only distinguished from each other by artificial characters which separate closely allied plants and bring together some having many distinct characters. The obvious similarity of the seeds to those of certain species of *Psychotria* (*P. tetragona*, Seemann, and allies), finally decided the genus.

Coprosma Imthurniana, *Gibbs in Journ. Linn. Soc., Bot.* xxxix. (1909) p. 154.

Nandarivatu, in flower and young fruit Nov. 24th, 1906, *im Thurn*, 280.

Distr. Fiji (Viti Levu).

A small tree, 4·5 m. high.

The leaves are somewhat larger and broader than in the type.

COMPOSITÆ.

*Tridax procumbens, *Linn. Sp. Pl.* p. 900.

Nandarivatu, in flower Feb. 4th, 1906, *im Thurn*, 77.

Distr. A native of America, now introduced into many parts of the world. Universally distributed in Fiji and said to be a recent introduction.

*Emilia sonchifolia, *DC. Prod.* vi. p. 302.

Nandarivatu, about Suva and most places where Europeans go, in flower March 2nd, 1906, *im Thurn*, 130.

Distr. Tropical Asia and Africa, but introduced as a weed into many countries.

GOODENIACEÆ.

Scævola floribunda, *A. Gray in Proc. Amer. Acad.* v. (1861) p. 152; *Seemann, Fl. Vit.* p. 146; *Gibbs, l. c.* p. 155.

Nandarivatu, in flower Nov. 21st, 1906, *im Thurn*, 263.

Distr. Fiji (Vitu Levu, Tonga).

A small tree, widely distributed.

VACCINIACEÆ.

Agapetes vitiensis, *Drake, Illust. Fl. Ins. Mar. Pacif.* p. 243; *Gibbs, l. c.* p. 155. *Paphia vitiensis*, Seemann in Journ. Bot. ii. (1864) p. 77, et Fl. Vit. p. 147, t. 28.

Top of Mt. Victoria, 1500 m., in flower May 1st, 1905.

Distr. Fiji (Viti Levu).

The native name is "vunga indina," and native tradition makes the plant come "from the flood." The flowers are crimson. Seemann's plate is either badly coloured or perhaps faded. The leaves are somewhat smaller, more dentate, and more acuminate than in the type, but no other differences have been found.

MYRSINACEÆ.

*Embelia gracilis, *Turrill,* sp. n. *E. floribundæ,* Wall., affinis, sed foliis minoribus ovatis, inflorescentia gracilore valde distincta.

Frutex repens (ex *im Thurn*), ramis teretibus primo minute glandulosis mox glabrescentibus. *Folia* ovata, apice obtuse acuminata, basi rotundata, 2–4 cm. longa, 1–2·3 cm. lata, chartacea, glabra, integra, costa nervisque pagina utraque subprominentibus, nervis lateralibus circiter 7 marginem versus sursum curvatis, punctis numerosis distinctis æquidistanter dispositis instructa; petioli 5–8 mm. longi, minute glandulosi. *Inflorescentia* ♂ ramulos laterales terminans, circiter 3 cm. longa et 2·5 cm. diametro, minute et dense ferrugineo-glandulosa; pedicelli 2·5 mm. longi, graciles; bracteæ fere 1 mm. longæ, dense ferrugineo-glandulosæ. *Sepala* 4, basi distincte connata, triangularia, apice acuta, fere 0·75 mm. longa, 0·5 mm. lata, dorso minute glandulosa. *Petala* 4, elliptico-oblonga, apice rotundata, 1·5 mm. longa, 0·75 mm. lata, punctata. *Stamina* 4, glabra, filamentis 0·75 mm. longis, antheris 0·25 mm. longis. *Ovarii* rudimentum 0·25 mm. altum, glabrum.

Navai, in flower March 28th, 1906, *im Thurn*, 200.

A shrubby creeper with minute white flowers.

Ardisia Brackenridgei, *Mez in Engler, Pflanzenreich,* iv., 236, p. 127. *Myrsine Brackenridgei,* A. Gray in Proc. Amer. Acad. v. (1861) p. 330; Seemann, Fl. Vit. p. 149. *Ardisia vitiensis,* Seemann, Fl. Vit. p. 150.

Nandarivatu, old Nadrau Road, in fruit Nov. 24th, 1906, *im Thurn*, 282.

Distr. Fiji (Viti Levu).

A shrub 6 feet high, with berries like red currants.

STYRACACEÆ.

Symplocos leptophylla, *Turrill,* sp. n. Affinis *S. Stawellii,* F. Muell., sed foliis oblongo-ellipticis non elliptico-oblanceolatis basi acutis differt.

Arbor ramis glabris vel junioribus leviter puberulis sicco brunneis vel flavo-brunneis vel junioribus flavo-viridibus. *Folia* oblongo-elliptica, apice acuminata, acumine usque ad 1 cm. longo, basi acuta, usque ad 12 cm. longa (acumine incluso) et 5 cm. lata, integra vel leviter crenata, nervis lateralibus utrinque circiter 7 pagina superiore subprominentibus inferiore prominentibus, costa supra impressa infra valde prominente; petiolus usque ad 1·5 cm. longus, fere glaber. *Inflorescentia* axillaris vel terminalis, usque ad 4 cm. longa, simplex vel ramosa, puberula; bracteæ ovatæ, 2 mm. longæ, 1·5 mm. latæ, extra puberulæ, intra glabræ; bracteolæ ovatæ, 1·3 mm. longæ, 1 mm. latæ, extra puberulæ, intra glabræ; pedicelli circiter 1 mm. longi. *Sepala* 5, oblongo-ovata, obtusa, 2·25 mm. longa, 1·25–1·5 mm. lata, extra adpresse puberula, intra glabra, margine ciliata. *Petala* 5, late ovata, obtusa, 3 mm.

longa, 2·5 mm. lata. *Stamina* ∞, indistincte pentadelpha. *Ovarium* semi-inferum ; stylus usque ad 1·5 mm. longus. *Fructus* immaturatus ovoideo-ellipsoideus, superne contractus, calyce persistente coronatus, glaber.—*S. Stawelii*, F. Muell., var. *leptophylla*, Brand in Engler, Pflanzenreich, iv., 242, p. 37. *S. spicata*, Seem. in Fl. Vit. p. 153, non Roxb.

Fiji (Kandavu), *Seemann*, 294.

Forma COMPACTA, *Turrill*, forma nova, a planta typica inflorescentiis compactis differt.

Nandarivatu, in flower March 30th, 1906, *im Thurn*, 225.

A tree with white flowers.

The genus *Symplocos* is exceedingly difficult from a taxonomic point of view, and our knowledge of many of the species is still very imperfect in spite of Brand's recent monograph in Engler's Pflanzenreich. This applies especially to the Polynesian species, the Kew material of which the monographer had not seen, and it is therefore not surprising that a careful examination of it has shown the necessity of making certain alterations in the nomenclature and status of the Fiji plants accepted by Brand.

Seemann was the first to name Fiji material *S. spicata*, Roxb. This species, originally described from Indian plants, differs from *S. leptophylla* in its nearly globose fruits and generally longer, more branched inflorescences. Brand (*l. c.*) recognized that the Fiji plants were distinct from *S. spicata*, Roxb., and referred part of Seemann's specimens to a new variety (?) *leptophylla* of *S. Stawellii*, F. Muell. This latter is, however, a distinct species, not yet found in Fiji, and easily distinguished from Seemann's plants by its elliptic-oblanceolate leaves. The specific diagnosis of *S. leptophylla* has been drawn up entirely from Seemann, 294, *i. e.* from the co-type of *S. Stawellii*, F. Muell., var. *leptophylla*, Brand. Most of the remaining Fiji specimens which have been generally referred to *S. spicata*, Roxb., are merely forms of *S. leptophylla*, though extremes might seem to warrant varietal or even specific rank were it not for the existence of intermediates. One of the most striking forms is that represented by *im Thurn*, 225. This has broader and more coriaceous leaves than the type and compact inflorescences.

APOCYNACEÆ.

*MELODINUS GLABER, *Turrill*, sp. n. *M. vitiensi*, Rolfe, affinis, sed inflorescentia et axillari et terminali omnino glabra distinguenda.

Frutex scandens (ex *im Thurn*), ramis teretibus glabris. *Folia* ovato- vel oblongo-lanceolata, apice obtusa, basi acuta, circiter 7 cm. longa, 2·5–3·5 cm. lata, membranacea, glaberrima, integra, costa supra impressa infra prominente, nervis lateralibus numerosis pagina utraque prominulis ad marginem anastomosantibus, nervis transversis uti reticulatione subconspicuis ; petioli 5–7 mm. longi, glabri. *Inflorescentia* et terminalis et axillaris, 10–25-flora,

glabra ; bracteæ circiter 1 mm. longæ, subacutæ, glabræ ; bracteolæ 1 mm. longæ, acutæ vel subobtusæ, glabræ, circiter petioli medium dispositæ ; pedunculi 3–4 mm. longi. *Calyx* 2 mm. longus, 2 mm. diametro, glaber ; segmenta 5, apice acuta. *Corollæ* tubus 5 mm. longus, basi 1·25 mm. diametro, supra staminum insertionem inflatus, fauce squamis fimbriatis ornatus, extra glaber, intra (basi excepta) pubescens ; lobi 5, suborbiculares, 2·5 mm. longi, glaberrimi. *Stamina* 5, filamentis 0·5 mm. longis, antheris 1·25 mm. longis, apice acutiusculis, loculis basi obtusis. *Discus* 0. *Ovarium* conicum, integrum, 1·25 mm. altum, 0·75 mm. diametro, typice biloculare et multiovulatum ; stylus (stigmate incluso) 2·5 mm. longus.

Nandarivatu, by "Governor's Seat," in flower Jan. 31st, 1906, *im Thurn*, 60. A creeper with small white flowers.

*Alstonia montana, *Turrill.* *A. plumosæ*, Labill., affinis, sed floribus majoribus, inflorescentiæ foliis brevioris ramis brevioribus differt.

Arbor parva (ex *im Thurn*), ramis teretibus glabris. *Folia* oblongo-lanceolata, apice obtusa vel leviter retusa, basi in petiolum angustata, usque ad 9·5 cm. longa et 3 mm. lata, subcoriacea, glaberrima, integra, costa supra distincte canaliculata infra prominente, nervis lateralibus circiter 12 supra indistincte canaliculatis infra leviter prominentibus ad marginem anastomosantibus, nervis transversis plus minusve distincte reticulatis ; petioli 1·5–2 cm. longi, glabri, supra canaliculati. *Inflorescentia* terminalis, multiflora, glabra ; bracteæ fere 1 mm. longæ, glabræ ; bracteolæ infra petioli medium dispositæ, circiter 0·5 mm. longæ, glabræ. *Calyx* 2 mm. longus, 2·5 mm. diametro : segmenta 5, apice subacuta. *Corollæ* tubus cylindricus, supra medium inflatus, 5 mm. longus, basi 1·5 mm. diametro, extra glaber, intra pubescens ; lobi 5, lanceolato-ovati, acuti, 5 mm. longi, 2 mm. lati, infra glabri, supra faucem versus pubescentes. *Stamina* 5, paulo supra tubi medium inserta, filamentis fere 1 mm. longis, antheris 1·5 mm. longis liberis acutiusculis, loculis basi obtusis. *Ovarium* conicum, 1 mm. longum, 1 mm. diametro, glabrum, typice biloculare et multiovulatum ; stylus (stigmate incluso) 2·5 mm. longus. *Discus* annularis, obscurus. *Folliculi* 2, lineares, 12–13 cm. longi, circiter 3 mm. diametro, glabri, longitudinaliter lineati. *Semina* oblonga, apice basique attenuata et bifida, 6 mm. longa, 2·5 mm. lata, plano-compresso, dense puberula, margine insigniter ciliata.

Nandarivatu, by "Governor's Seat," in flower and fruit Jan. 31st, 1906, *im Thurn*, 58.

Ervatamia orientalis, *Turrill*, comb. nov. *Tabernæmontana orientalis*, R. Brown, Prod. p. 468 ; Seemann, Fl. Vit. p. 159.

Nandarivatu, in flower Feb. 4th, 1906, *im Thurn*, 75.

Distr. Fiji (Viti Levu, Wakaki), Australasia, Malaya.

*Carruthersia scandens, *Seemann, Fl. Vit.* p. 156.

Nandarivatu, in flower Feb. 24th, 1906, *im Thurn*, 114; also in flower Feb. 26th, 1906, *im Thurn*, 121.

Distr. Fiji (Viti Levu, Vanua Levu, Ovalau, Rambe (or Rabi)).

There are two apparently well-marked forms of this species. The first (represented by Seemann's type, *Storck*, 901, and *im Thurn*, 121) has oblong-ovate leaves rounded or subcordate at the base, and corolla-tubes 2 cm. in length. The second (represented by *im Thurn*, 114) has ovate leaves, distinctly cordate at the base, and corolla tubes 1 cm. long.

ASCLEPIADACEÆ.

Hoya australis, *R. Brown ex Traill in Trans. Hort. Soc.* vii. (1830) p. 28; *Bentham, Fl. Austral.* iv. p. 246; *Gibbs in Journ. Linn. Soc.* xxxix. (1909) p. 157. *H. bicarinata*, A. Gray in Proc. Amer. Acad. vol. v. (1861) p. 335; Seemann, Fl. Vit. p. 163.

Nandarivatu, near settlement, in flower Nov. 30th, 1906, *im Thurn*, 296; without locality, in flower Feb. 8th, 1906, *im Thurn*, 86.

Distr. Fiji (Viti Levu, Vanua Levu), Tonga Islands, New Hebrides, N.E. Australia.

im Thurn, 322, Nandarivatu, Dec. 5th, 1906, is a species of *Hoya* closely related to *H. australis*, R. Brown, but the specimens are insufficient for determination.

Hoya diptera, *Seemann in Bonplandia*, vol. ix. (1861) p. 257, et *Fl. Vit.* p. 163.

Suva, on Ivi trees in Government House paddock, in flower April 7th, 1905, *im Thurn*, F 7.

Distr. Fiji (Viti Levu).

Flowers yellow, *i. e.* "naiskun" coloured.

*Hoya megalantha, *Turrill*, sp. n. *H. bicarinata*, A. Gray, affinis, sed foliis angustioribus attenuate acuminatis, floribus majoribus differt.

Rami teretes, glabri vel sparsissime pubescentes. *Folia* elliptico-ovata, apice attenuate acuminata, basi rotundata, usque ad 6·5 cm. longa et 3 cm. lata, integra, glaberrima, subcoriacea, vix carnosa, costa supra impressa infra prominente, nervis lateralibus utrinque circiter 5 pagina utraque subprominentibus, transversis uti reticulatione subprominentibus; petioli circiter 1 cm. longi, teretes, glabri. *Inflorescentia* umbellata, 5–7-flora; pedunculi pedicellique graciles, teretes, glabri, illis 1–2·8 cm. longis, his 3·5 cm. longis. *Sepala* subtriangularia, apice subobtusa, 2·5 mm. longa, 1·5 mm. lata, distincte ciliata. *Corolla* late cyathiformis vel fere rotata, circiter ad medium divisa, usque ad 5 cm. diametro, intus omnino minute papillosa, extus glabra, lobis 5

triangularibus acutis usque ad 1·3 cm. longis et 1·4 cm. latis ; coronæ radii 5 mm. longi, medio 3·5 mm. lati, nitentes, glabri. *Pollinia* oblonga, 1·25 mm. longa.

Mt. Victoria, 1500 m., in flower May 1st, 1905 ; Mt. Washington (Nabukelevu), Kandavu, in flower April 4th, 1905, *im Thurn*, F 6.

The flower is a rather deep purple.

*HOYA VITIENSIS, *Turrill*, sp. n. *H. subcalvæ*, Burkill, affinis, sed corolla intus dense pustulata, coronæ radiis latioribus distinguenda.

Rami subteretes, glabri. *Folia* elliptico-oblonga vel elliptico-ovata, apice attenuate acuminata, basi rotundata vel subcordata, usque ad 10 cm. longa et 7 cm. lata, integra, glaberrima, nervis lateralibus utrinque circiter 7 marginem versus anastomosantibus siccitate cum costa pagina utraque prominentibus, transversis uti reticulatione prominentibus ; petioli 0·5–1·5 cm. longi, crassiores, glabri. *Inflorescentia* umbellata, circiter 12–15-flora ; pedunculi graciles, teretes, 4·5 cm. longi ; pedicelli graciles, teretes, 3·8 cm. longi, glabri. *Sepala* 5, subtriangularia, subacuta, 1·75 mm. longa, 1·5 mm. lata, distincte ciliata. *Corolla* ad medium divisa, 2 cm. diametro, intus omnino pustulata, 5-lobata, lobis 5 mm. longis 7 mm. latis acutis ; coronæ radii 4 mm. longi medio 2·75 mm. lati, glabri, nitentes. *Pollinia* 1 mm. longa.

Nandarivatu, in flower Nov. 20th, 1906, *im Thurn*, 260.

LOGANIACEÆ.

FAGRÆA BERTERIANA, *A. Gray ex Benth. in Journ. Linn. Soc.* vol. i. (1857) p. 98 ; *Seemann, Fl. Vit.* p. 164.

Suva, in flower Dec. 16th, 1906, *im Thurn*, 16 (?).

Distr. Fiji (Viti Levu, Vanua Levu, Ovalau), and generally throughout the South Pacific Islands. The native name is "Bua."

SOLANACEÆ.

SOLANUM INAMŒNUM, *Benth. in Hook. Lond. Journ. Bot.* vol. ii. (1843) p. 228. *S. tetrandrum*, Seemann, Fl. Vit. p. 176 pro parte, non R. Brown.

Nandarivatu, along the road to Suva, in the shade of the forest, in flower and fruit Nov. 27th, 1906, *im Thurn*, 294.

Distr. Fiji (Viti Levu).

A shrub 5 feet high, with inconspicuous white flowers and smooth purple fruit.

This plant differs from *S. tetrandrum*, R. Brown, in the larger fruits, almost sessile fascicles of flowers, and more acuminate leaves with impressed nerves above. The type of *S. inamœnum*, Benth., has broader leaves than Sir Everard im Thurn's specimens, but the fruits, inflorescence, and nervation of the leaves are the same in both plants.

*SOLANUM TORVUM, *Swartz, Prodr.* 47.

Nandarivatu, in flower and fruit Nov. 22nd, 1906, *im Thurn*, 273.

Distr. India, China, Malaya, Tropical America.

A shrub 8 to 10 feet high, flowers white, sometimes with a purplish tinge; very common in waste places all over the colony.

VERBENACEÆ.

PREMNA TAITENSIS, *Schauer in DC. Prod.* xi. p. 638; *Seemann, Fl. Vit.* p. 186; *Gibbs in Journ. Linn. Soc.* xxxix. (1909) p. 160.

Nandarivatu, in the forest, in flower Nov. 27th, 1906, *im Thurn*, 295.

Distr. Fiji (Viti Levu, Ovalau, Moala, Nairai) and most of the Polynesian groups.

A tree 30 feet high, with *Viburnum*-like flowers.

PIPERACEÆ.

PIPER MACGILLIVRAYI, *Casim. DC. in Seemann, Fl. Vit.* p. 262, t. 75, et in *DC. Prodr.* xvi. p. 335.

Nandarivatu, in flower March 23rd, 1906, *im Thurn*, 176.

Distr. Fiji (Viti Levu, Taviuni, Kandavu, Matuku), Samoa, Tonga Islands.

Var. FASCICULARIS, *Warb. in Engl. Jahrb.* xxv. (1898) p. 609.

Nandarivatu, in flower and fruit Dec. 3rd, 1906, *im Thurn*, 304.

Distrib. Fiji (Viti Levu), Samoa.

"False yagona," short fruit.

The leaves and petioles are glabrous and the spikes about 2 cm. long, excluding the peduncle, which is about 1 cm. in length. From one to four spikes arise in the axil of each leaf.

PEPEROMIA PALLIDA, *A. Dietr. Sp. Pl.* i. p. 153.

Mount Victoria, 1500 m., in flower May 1st, 1905, *im Thurn*, 29, 30; Nandarivatu, by the water supply, in fruit Nov. 26th, 1906, *im Thurn*, 285.

Distr. Fiji (Viti Levu, Ovalau), Tahiti, Samoa.

LAURACEÆ.

*LITSEA IMTHURNII, *Turrill*, sp. n. *L. firmæ*, Hook. f., affinis, foliis glabris vel fere glabris, nervis pagina inferiore minus prominentibus distinguenda.

Arbor (ex *im Thurn*), ramis teretibus primo puberulis mox glabrescentibus. *Folia* alterna, oblongo-elliptica, apice rotundata vel leviter retusa, basi rotundata, usque ad 1·2 cm. longa et 4·75 cm. lata, integra, subcoriacea, glabra vel pagina inferiore leviter puberula, nervis lateralibus utrinque

circiter 10 marginem versus indistincte anastomosantibus, cum costa pagina superiore impressis, inferiore prominentibus, nervis transversis supra inconspicuis subtus subprominentibus; petioli 1·5–2 cm. longi, leviter puberuli. *Flores* ♂, in umbellas circiter 6-floras pedunculatas aggregati; umbellæ 5–7 in fasciculos axillares vel ex axillis foliorum delapsorum dispositæ; pedunculi teretes, 1 cm. longi, dense pubescentes; pedicelli 3 mm. longi, dense pubescentes; bracteæ 5, late ovatæ vel subrotundatæ, concavæ, apice rotundatæ, usque ad 5 mm. longæ et 5·5 mm. latæ, extus dense pubescentes, intus glabræ. *Perianthii* tubus campanulatus, 1·5 mm. longus, dense pubescens; lobi 6, oblongo-obovati, apice rotundati, 3 mm. longi, 1·5 mm. lati, extus adpresse pubescentes, intus glabri. *Stamina* 12, exteriora eglandulosa, filamentis 2 mm. longis leviter pubescentibus, antheris 1 mm. longis obtusis, interiora filamentis 1·5 mm. longis glandulis 2 sessilibus instructis, antheris 1 mm. longis obtusis. *Gynæceum* rudimentarium, 1·5–2 mm. longum; ovarium 0·5 mm. longum, dense pubescens.

Nandarivatu, in flower March 30th, 1906, *im Thurn*, 224.

A tree with yellow fluffy flowers.

*Litsea montana, *Turrill*, sp. n. *L. vitianæ*, Drake, affinis, sed foliis latioribus, nervis lateralibus utrinque 3–4, umbellis bifloris differt.

Arbor (ex *im Thurn*), ramis teretibus glabris. *Folia* alterna, latissime elliptica vel subrotundata, apice obtuse acuminata, basi acuta, usque ad 9 cm. longa et 5 mm. lata, integra, subcoriacea, glaberrima, nervis lateralibus utrinque 3–4 marginem versus sursum leviter curvatis, cum costa pagina superiore subprominentibus, inferiore prominentibus, nervulis uti reticulatione conspicuis; petioli 1–1·5 cm. longi, glabri. *Flores* ♀, subsessiles, in umbellas semper bifloras pedunculatas aggregati; umbellæ 2–3 in fasciculos axillares dispositæ; pedunculi 5 mm. longi, adpresse pubescentes; bracteæ 4, subrotundatæ, 2·5 mm. longæ, 3 mm. latæ, apice rotundatæ, extra pubescentes, intus glabræ. *Perianthii* tubus 1 mm. longus, extra adpresse pubescens; lobi 6, oblongi, 1·25 mm. longi, 0·75 mm. lati, extra adpresse pubescentes, intus glabri. *Staminodia* 12, omnia subsimilia, 1·25 mm. longa, glandulis 2 sessilibus instructa. *Ovarium* ovoideum, 1 mm. altum, 1 mm. diametro, glabrum, typice uniovulatum; stylus 0·5 mm. longus, glaber; stigma peltatum, 1 mm. diametro.

Nandarivatu, in flower March 29th, 1906, *im Thurn*, 217.

PROTEACEÆ.

*Kermadecia vitiensis, *Turrill*, sp. n. Affinis *K. ellipticæ*, Brongn. et Gris, sed foliis omnibus pinnatis, inflorescentia graciliore, floribus minoribus sæpissime 2 ad apicem pedicellorum connatorum gestis præcipue recedit.

Arbor (ex *im Thurn*), ramis teretibus minute ferrugineo-puberulis indistincte longitudinaliter lineatis. *Folia* omnia pinnata, pari- vel impari-pinnata, usque ad 24 cm. longa et 17 cm. lata; petiolus teres, 3–5 cm. longus, leviter puberulus vel fere glaber; rhachis usque ad 12 cm. longa, leviter puberula vel fere glabra; foliola circiter 8, alterna vel opposita, late lanceolata, apice subobtusa, basi sæpe obliqua, rotundata vel acuta, usque ad 10·5 cm. longa et 4 cm. lata, integra vel apicem versus dentibus duobus instructa, matura supra nitentia, infra opaca, nervis lateralibus utrinque circiter 5 sursum valde curvatis cum costa pagina utraque prominentibus, nervis transversis uti reticulatione prominentibus; petiolulus circiter 1 cm. longus. *Paniculæ* 5–15, ramulorum apicem versus dispositæ, multifloræ; pedunculi teretes, 2–3·5 cm. longi, ferrugineo-pubescentes; pedicelli singuli vel bini ad summum apicem connati, 0·5 cm. longi, ferrugineo-pubescentes; bracteæ minutissimæ. *Perianthii* lutei (ex *im Thurn*) tubus cylindricus, leviter incurvus, segmentis 4 per anthesin solutis, laminis ovatis concavis 2·5 mm. longis 1·5 mm. latis extus ferrugineo-puberulis intus glabris. *Antheræ* 4, in laminis subsessiles, oblongæ, 2·25 mm. longæ, 0·5 mm. latæ, connectivo latiusculo apice breviter apiculato. *Discus* hypogynus, semiannulatus, unilateralis, 1 mm. altus, carnosus, glaber, breviter bilobatus. *Ovarium* cylindricum, in receptaculo obliquo, subsessile, 2·5 mm. altum, 0·5 mm. diametro, glabrum, ovulis 2 collateralibus ab loculi apice pendulis; stylus 6 mm. longus, glaber; stigma clavatum, 1·5 mm. longum, obliquum.

Nandarivatu, in flower March 14th, 1906, *im Thurn*, 149.

A yellow-flowered tree in the jungle beyond the tennis court. Very conspicuous.

THYMELÆACEÆ.

Wikstrœmia fœtida, *A. Gray*, var. vitiensis, *A. Gray in Seemann, Journ. Bot.* iii. (1865) p. 302; *Seemann, Fl. Vit.* p. 207.

Nandarivatu, by the "Governor's Seat," in flower Jan. 31st, 1906, *im Thurn*, 56.

Distr. Fiji (Viti Levu).

A shrub or very small tree.

*Leucosmia glabra, *Turrill*, sp. n. *L. acuminatæ*, A. Gray, affinis, sed foliis coriaceis, ovario glabro distinguitur.

Arbor vel frutex, ramis teretibus glabris. *Folia* ovato-lanceolata vel oblongo-lanceolata, apice acuta vel leviter acuminata, basi acuta vel subrotundata, usque ad 15 cm. longa et 7 cm. lata, coriacea, glabra, integra, nervis lateralibus circiter 8 pagina utraque conspicuis; petioli usque ad 1 cm. longi, glabri. *Inflorescentia* axillaris (an semper?), multiflora, umbellis 1–3-aggregatis; involucri bracteæ 2, late orbiculares, circiter 1 cm. longæ

et 1·3 cm. latæ, apice rotundatæ. *Perianthii* tubus 4 cm. longus, infra cylindricus, 1 mm. diametro, superne leviter et sensim ampliatus, extra glaber, intra pubescens; limbi lobi 4, elliptico-oblongi, apice rotundati, 8 mm. longi, 4·5 mm. lati, extra glabri, intra dense pubescentes; squamæ lobis alternatæ, truncatæ, fere 1 mm. longæ. *Stamina* 8, filamentis 1 mm. longis glabris, antheris 1·75 mm. longis. *Discus* cupuliformis, irregulariter lobatus, 2 mm. altus, glaber. *Ovarium* turbinatum, glabrum, 2-loculare, loculis uniovulatis; stylus 5 cm. longus, glaber, stigmate capitato indistincte bilobato.

Kandavu, in flower March 1912, *im Thurn*, 12.

Common about Nandarivatu.

EUPHORBIACEÆ.

*MACARANGA GRANDIFOLIA, *Turrill*, sp. n. *M. macrophyllæ*, Muell.-Arg. affinis, sed foliis longioribus nervis lateralibus numerosioribus distinguenda.

Arbor parva (ex *im Thurn*), ramis teretibus glabris vel leviter puberulis. *Folia* oblongo-ovata, apice obtusa vel rotundata, basi peltata, usque ad 5 dcm. longa et 3 dcm. lata, margine integra vel leviter et plus minusve irregulariter crenata, supra nervis hispida, infra juniora nervis hispida, omnia glandulis minutis sessilibus dense tecta, nervis primariis circiter 7, nervo principali nervis lateralibus utrinque 15 instructo, nervis transversis numerosis parallelis, nervis omnibus pagina superiore subprominentibus vel impressis, inferiore prominentibus; petiolus circiter 25 cm. longus, sparse hispidus vel glaber; stipulæ oblongo-lanceolatæ, 4 cm. longæ, 1·5 cm. latæ, acutæ, integræ, extus glandulis sessilibus dense tectæ. *Flores* ♂, numerosi, sessiles, 4–8 in fasciculos aggregati; fasciculi in paniculas ramosissimas dispositi, paniculæ ramis glabris; bracteæ florales subrotundatæ, sessiles, glabræ, flores 4–8 subtendentes. *Calyx* 3–4-lobus, rufus, glaber. *Stamina* circiter 7–12, typica.

Nandarivatu, on the edge of the forest; flowers young; March 6th, 1906, *im Thurn*, 134.

A small tree, like a huge nettle, with crimson flowers.

LORANTHACEÆ.

LORANTHUS INSULARUM, *A. Gray, Bot. U.S. Expl. Exp.* p. 738, t. 98; *Seemann, Fl. Vit.* p. 120; *Gibbs in Journ. Linn. Soc.* xxxix. (1909) p. 168.

Nandarivatu, in flower Nov. 19th, 1906, *im Thurn*, 255.

Distr. Fiji (Viti Levu, Nairai, Matuku), Loyalty Islands, Tonga Islands, Society Islands, Rarotonga.

The flowers are scarlet and black.

URTICACEÆ.

*PELLIONIA ELATOSTEMOIDES, *Gaud.*, var. PUBESCENS, *Turrill*, var. nov. A planta typica foliis utrinque plus minusve pubescentibus, inflorescentia ♂ majore ramosiore recedit.

Nandarivatu, by the water supply, in flower (♂ only) Nov. 26th, 1906, *im Thurn*, 286.

PELLIONIA FILICOIDES, *Seemann, Fl. Vit.* p. 239.

Without locality and number.

Distr. Fiji (Viti Levu, Ovalau).

In the writer's opinion *P. vitiensis*, A. Gray ex Weddell in DC. Prodr. xvi. p. 167, is this species.

PROCRIS MONTANA, *Steud. Nomencl.* ed. 2, ii. p. 398; *Gibbs in Journ. Linn. Soc.* xxxix. (1909) p. 172. *Elatostema montanum*, Endl. Prod. Fl. Ins. Norf. p. 39.

Nandarivatu, along the Ba road near the first mile-post, in fruit Nov. 24th, 1906, *im Thurn*, 283.

Distr. Fiji (Viti Levu), Norfolk Island.

The leaves are smaller than those of Bauer's specimen from Norfolk Island in Herb. Kew. No other difference has been found, and the plant is certainly the same species as that collected by Miss Gibbs at Nandarivatu.

MISSEISSYA CORYMBULOSA, *Weddell, Urticac.* p. 475; *Seemann, Fl. Vit.* p. 244.

Nandarivatu, in flower Feb. 3rd, 1906, *im Thurn*, 69.

Distr. Fiji (Viti Levu, Ovalau, Taviuni, Ngau, Totoya, Matuku, Nairai), Samoa.

LILIACEÆ.

SMILAX VITIENSIS, *A. DC. Monogr. Phan.* i. p. 204; *Gibbs, l. c.* p. 178. *Pseudosmilax vitiensis*, Seemann, Fl. Vit. p. 310.

Nandarivatu, by the water supply, in flower Nov. 26th, 1906, *im Thurn*, 287.

Distr. Fiji (Viti Levu, Kandavu, Ovalau).

GEITONOPLESIUM CYMOSUM, *A. Cunn. in Bot. Mag.* t. 3131; *Seemann, Fl. Vit.* p. 312; *Gibbs, l. c.* p. 178.

Nandarivatu, in flower Feb. 8th, 1906, *im Thurn*, 85.

Distr. Fiji (Viti Levu, Kandavu), Norfolk Island, Lord Howe's Island, New Caledonia, Australia, Borneo.

The Vegetation of White Island, New Zealand. By W. R. B. Oliver. (Communicated by L. Cockayne, F.R.S., F.L.S.)

(Plates 2 & 3, and 2 Text-figures.)

[Read 6th February, 1914.]

The plant formations of White Island are of interest, as they exist under conditions scarcely paralleled elsewhere in the New Zealand region, namely, in the presence of fumes of hydrochloric acid. The volcano is in the solfatara stage and discharges from its crater immense quantities of steam: hence the name, White Island, bestowed on it by Captain Cook. It is a small cone, 48 km. from the nearest point on the mainland, and being surrounded by water 330 m. in depth, and of comparatively recent origin, it is probable that it has never been united to the mainland and has therefore received its plants by accidental dispersal. In extreme length it is 2·4 km., and its highest point, according to the Admiralty chart, is 328 m.

Viewed from the sea, White Island is a magnificent sight. The outer slopes of the crater are coloured pink, and have at their base and western end dark green patches of vegetation. From the south a portion of the sulphur-coloured cliffs within the crater is seen near the eastern end, while apparently from the top of the island issue immense columns of steam, which in fine weather rests as a white cloud above. On landing, one is faced by a gorgeous panorama formed by the precipitous inner walls of the crater. It is a veritable inferno, and care must be taken in exploring the crater floor, as all the steam, which escapes from innumerable fissures, is more or less charged with poisonous fumes. The cliffs are rather brightly coloured, yellow and red tints prevailing. A lake of greenish-yellow water, boiling in many places, stretches across from cliff to cliff (see Plate 2). From it rise clouds of greenish-yellow steam, which is of a particularly harmful nature, as it is heavily charged with hydrochloric acid fumes. Beyond the lake, from many blow-holes, there ascend huge columns of steam, which on reaching the crater-rim some 300 m. above are usually carried away by the wind.

White Island is composed of lava-tuffs with few streams of lava interstratified, sloping at a steep angle, about 25°, from a central crater, the inner walls of which are precipitous, but are broken away almost to sea-level at the eastern end. The tuffs consist of fragments of lava-rocks of various sizes loosely held together by finer material. The whole readily breaks down and crumbles away under the action of the weather. The outer slopes of the crater are therefore very steep, difficult and dangerous to walk over, as the stones give way at every step, and are deeply furrowed by innumerable channels often impassable on account of their precipitous sides of loose

detachable material. The pink colouring matter which gives the island its unique appearance is contained in a surface-deposit.

Probably the chief factor which determines the peculiarities of the vegetation is the poisonous steam which rises from the surface of the crater-lake. The analysis of samples of the water from this lake taken at different times gives slightly different results, but the amount of free hydrochloric acid present averages over five per cent.

The following by Dr. Maclaurin is taken from Professor Park's 'Geology of New Zealand' (Wellington, 1910).

	Grains per gallon.	Per cent.
Sodium sulphate	620	0·88
Ammonium sulphate	1733	2·48
Potassium sulphate	101	0·14
Ferrous and ferric sulphates	346	0·49
Calcium sulphate	351	0·50
Magnesium sulphate	182	0·26
Hydrochloric acid (free)	3832	5·47
	7165	10·22

Also present, silica (9 grains per gallon), and heavy traces of boric acid, arsenic, and copper.

The presence of hydrochloric-acid fumes in the atmosphere has the effect of contaminating all fresh water on the island, so that the sulphur-workers resident there have to procure their supplies in jars from the mainland. In foggy weather the air becomes particularly unpleasant, and it may then be said to rain dilute hydrochloric acid. Gannets (*Sula serrator*), which breed in large numbers on the island, are frequently disturbed by noxious fumes from the crater. No vegetation occurs within or on the upper slopes of the outside of the crater. The vegetation occurs near the coast only, and usually in three definable belts :—(1) The sea-cliffs and coastal slopes support a low growth of grasses and herbaceous plants ; (2) next follows a belt of dense scrub ; (3) followed by an open low shrub-formation. It is a significant fact that scrub occurs mainly on the southern and western sides of the island, for the prevailing winds being from the south-west, would usually carry the steam-clouds in a north-easterly direction. There can be little doubt also, that, in addition to the distribution of the vegetation on White Island, the paucity of species and the stunted character of the dominant plants are due to the harmful effects of hydrochloric-acid fumes.

No meteorological observations have been made on White Island, but, situated in S. lat. 37° 30′, its climate will be similar to that of Te Kaha and

Opotiki on the mainland. Winds are frequent, principally from the west and south-west. The following figures, which will serve to indicate approximately the climate of White Island for the year 1912–1913, are based on reports published in the 'New Zealand Gazette.'

	Te Kaha: Rainfall.		Auckland: Temperature.	
	mm.	Days.	Mean max. °C.	Mean min. °C.
1912. July	112	9	13·2	7·3
Aug.	105	7	13·6	6·7
Sept.	87	14	15·8	9·7
Oct.	104	8	16·6	10·1
Nov.	93	8	17·7	11·2
Dec.	14	5	20·8	13·4
1913. Jan.	225	12	22·3	14·9
Feb.	19	4	22·3	14·9
Mar.	71	6	22.3	14·5
Apr.	17	1	18·4	10·6
May	58	7	14·4	8·2
June	35	4	14·0	6·9
Means and totals	940	85	17·6	10·7

Sea-birds constitute a factor affecting the vegetation on White Island to some extent. The Gannet (*Sula serrator*) breeds in about six colonies on the south coast. Like the plants, its distribution is probably determined by the prevailing winds which carry fumes from the crater in a north-easterly direction. The areas occupied are quite clear of vegetation; indeed the presence of dead plants of *Metrosideros tomentosa* in the midst of some of the colonies, shows that the birds not only prevent the scrub from spreading, but actually kill any on ground they may occupy. In portions of the spaces cleared by Gannets, but not occupied at the time of my visit, there was a rank growth of herbaceous plants.

Certain areas in the scrub and on slopes facing the sea are occupied by colonies of the Grey-faced Petrel (*Œstrelata macroptera*). These birds breed in burrows, and in the course of their breeding-season completely undermine and overturn the soil in the portions they occupy. Their effect on the vegetation is seen in the luxuriant growth of grasses and herbaceous plants on the slopes and edge of the scrub facing the sea.

Plant-formations.

Scrub.—A belt of scrub runs along the south coast just above the sea-cliffs; on the western end of the island there is a considerable area covered with scrub (see Plate **3**); and on the north coast are a few patches, increasing in size towards the west. Where occupied by Petrels the soil will be fairly

rich in guano and vegetable-mould, and on the more level places some leaf-mould has collected, but along the upper portions of the scrub the soil is the ordinary volcanic tuff devoid of humus.

The scrub varies in height from three or four metres at its eastern end to six or eight near the west end of the island. It is composed of shrubs or small trees of irregular habit, but growing close together (see Plate **3**), and bearing the dense dark green foliage at the top. The floor is thickly strewn with dead leaves and branches, and gives one the impression that decomposition is slow. Dead branches and twigs attached to the living plants are a conspicuous feature, and dead trees still standing are occasionally met with. It is evident that the plants have a hard struggle for existence, and possibly the fumes in the atmosphere act as preservatives, inhibiting the decomposition of the dead parts. Except where broken into by colonies of Gannets, the scrub ends on all sides abruptly and compactly, the foliage descending to the ground. Open scrub occupies a belt above the closed formation, near which the plants are low, rounded, detached bushes one metre tall, but they gradually decrease in size and in number towards the inner edge of vegetation a little distance up the slope of the volcano.

The scrub is a pure association of *Metrosideros tomentosa*, A. Rich., no other species being seen except near the coast, where patches of the broad-leaved tussocks, one metre tall, of *Phormium tenax*, Forst., may occur, while on the sea-cliffs a few shrubs of *Coprosma Baueri*, Endl., are found.

Metrosideros tomentosa has the branchlets and under-surfaces of the leaves covered with woolly tomentum. The leaves are coriaceous with recurved margins, both surfaces with thick cuticle, and epidermis of a single layer of small cells. The mesophyll consists of three layers : (1) an upper, which may be water-storage tissue, of three or four rows of irregular thick-walled cells with few chloroplasts ; (2) then follow three rows of palisade-cells ; (3) below which is the spongy parenchyma of small cells. *Coprosma Baueri* has shining dark green leaves with recurved margins. The cells of the upper are larger than those of the lower epidermis, and both have thickened outer walls. The mesophyll consists of three layers : (1) a single layer of large flat cells next the upper epidermis ; (2) three rows of palisade-cells of which the upper are very much larger than the others ; (3) spongy parenchyma containing air-cavities. *Metrosideros robusta* has likewise a mesophyll consisting of three or four rows of palisade-cells between a layer of large cells next the upper epidermis and the spongy parenchyma of close small cells. The leaf-structure of the shrubs of White Island is thus essentially the same, and is distinctly xerophytic in character. No stomata were detected on the upper surface of the leaves of any of the species.

Perhaps the most nearly related formation in the New Zealand area is the scrub on Rangitoto Island in Auckland Harbour. Here is a lava-cone on which, over most of the surface, blocks of lava are irregularly piled, and rain-

water is mainly lost to plants. In many places, however, soil has collected and there is found a scrub-formation similar in structure to that of White

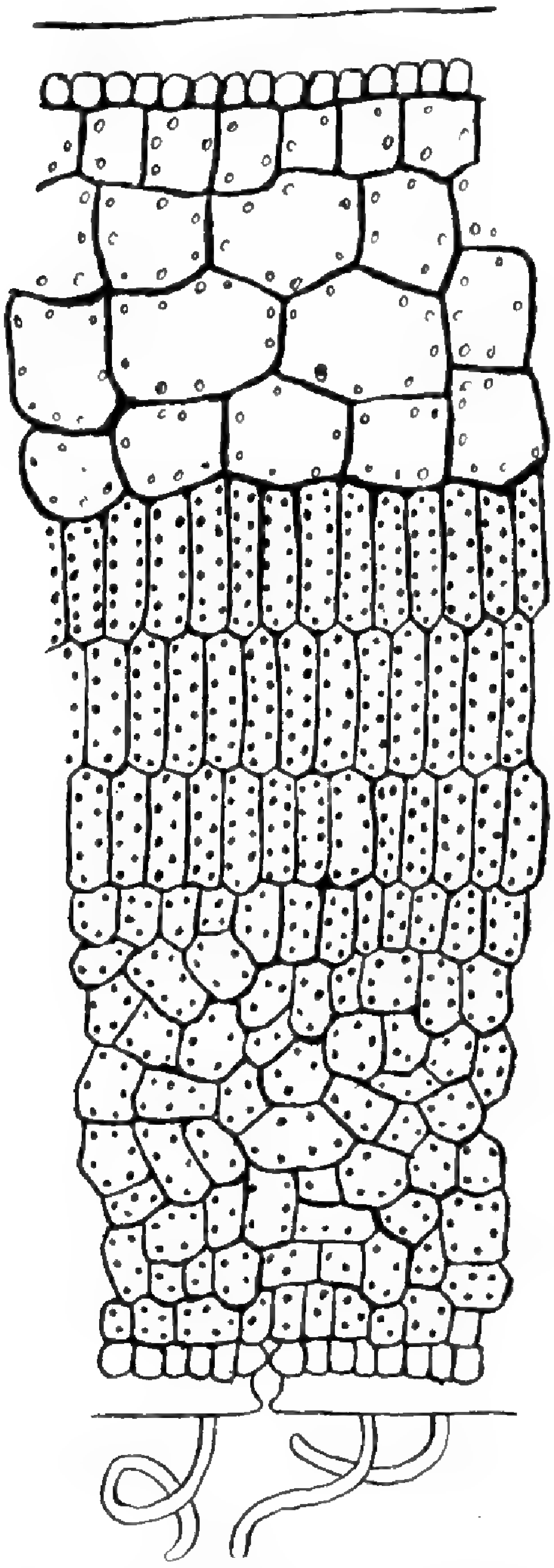


Fig. 1.—Section of leaf of *Metrosideros tomentosa*, A. Rich., magnified.

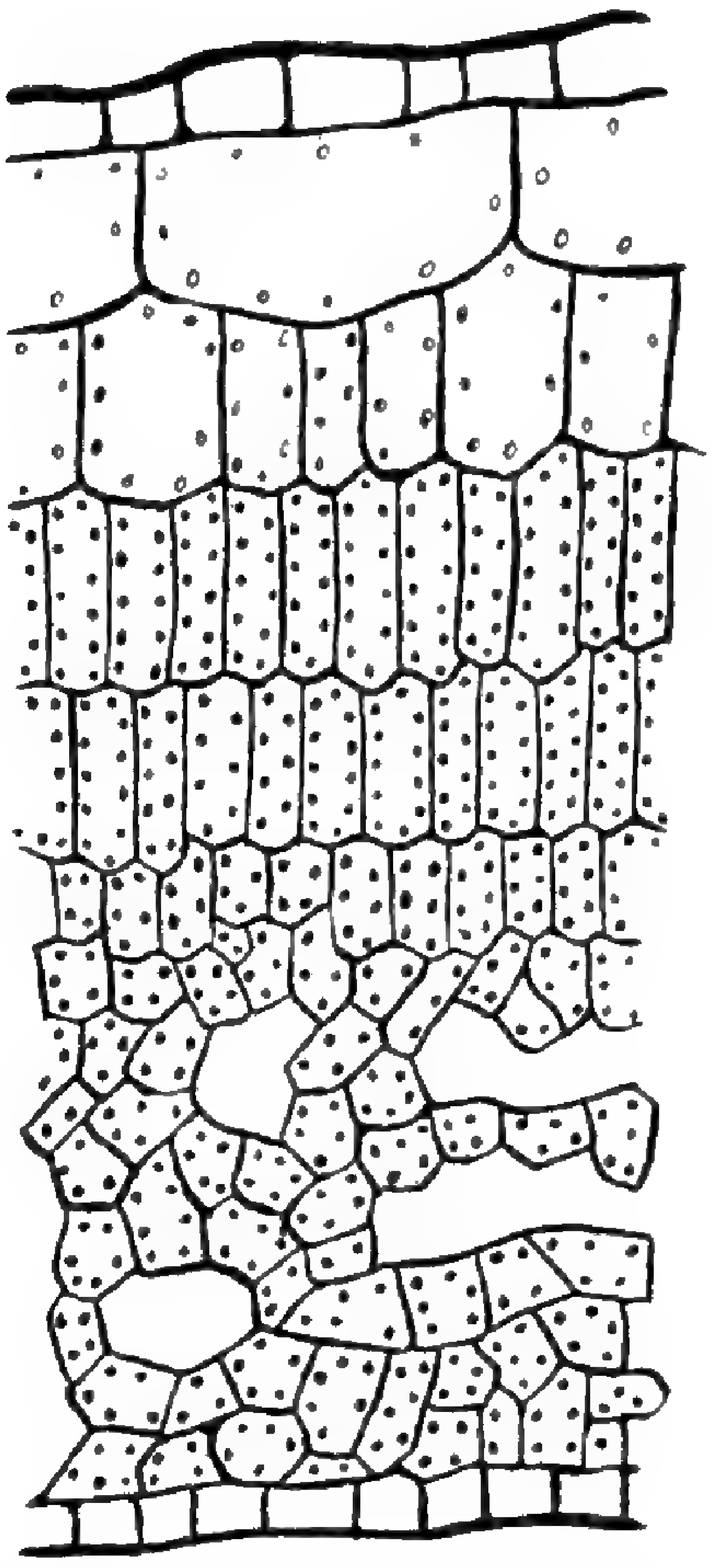


Fig. 2.—Section of leaf of *Coprosma Baueri*, Endl., magnified.

Island, with the addition of an undergrowth and composed of a number of different species. The dominant plant on the lower slopes of Rangitoto is *Metrosideros tomentosa*.

Coastal Cliffs.—This formation is best developed at the eastern end of the island, where *Metrosideros tomentosa* is represented by a few small shrubs only, and is found on the sea-cliffs and slopes below the scrub in other parts.

In many places the ground is undermined by Petrels, and here is usually a luxuriant growth of grass and herbs. In vacant portions of the clearings made by Gannets, there is likewise a rank growth of herbaceous plants. The soil in those portions occupied by sea-birds must contain a considerable quantity of guano; elsewhere it is a rocky surface with no humus.

The vegetation on the coastal cliffs and slopes not frequented by sea-birds is an open formation. Here occur small detached patches or single plants of a low, apparently tufted fern (*Histiopteris incisa*, Ag.), a tussock grass (*Poa anceps*, Forst. var *condensata*, Cheesem.), and the trailing succulent plant *Mesembryantheum australe*, Soland. Small shrubs of *Metrosideros tomentosa* also occur here. *Histiopteris incisa* in these situations has small fleshy fronds usually lacerated or dead at the margins. *Poa anceps* var. *condensata* is stunted and tufted with dense contracted panicles.

A close meadow formation occurs in those areas annually occupied by sea-birds. Near the Gannet colonies is a rank growth, under half a metre tall, of herbaceous plants. The principal species are *Chenopodium triandrum*, Forst., and *Sonchus oleraceus*, Linn., each occurring in distinct patches. On the slopes undermined by Petrels there is usually a dense growth of tangled grass (*Poa anceps* var. *condensata*), large patches of the succulent *Mesembryanthemum australe*, with small clumps of a low creeping fern (*Histiopteris incisa*), and here and there a small shrub of *Metrosideros tomentosa* or *Coprosma Baueri*.

List of Species.

Histiopteris incisa (Thunb.), J. Sm.
Coastal cliffs and rocks.
Widely distributed in tropical and south temperate regions.

Poa anceps, Forst. f., var. *condensata*, Cheesem.
Coastal cliffs and rocks.
New Zealand as far south as Canterbury.

Deyeuxia Forsteri, Kunth.
Shingle beach (rare).
New Zealand, Tasmania, Australia.

Phormium tenax, Forst.
Outer edge of scrub (not common).
New Zealand, from Auckland Island north to Norfolk Island.

Chenopodium triandrum, Forst. f.
Near Gannets.
New Zealand.

Mesembryanthemum australe, Soland.
Coastal cliffs and rocks.
New Zealand, Tasmania, Australia.

FIG. 1.

The Crater Lake. Grout, photo sc.

FIG. 2.

Gannets with *Metrosideros* Scrub. Grout, photo sc.

WHITE ISLAND.

Grout, photo sc.

WHITE ISLAND.

Interior of *Metrosideros* Scrub.

Metrosideros tomentosa, A. Rich.
Scrub, coastal cliffs, and rocks.
New Zealand north of S. lat. 39°.

Metrosideros robusta, A. Cunn.
New Zealand north of S. lat. 43°.

Solanum nigrum, Linn.
Near Gannets.
Cosmopolitan.

Coprosma Baueri, Endl.
Coastal cliffs (not common).
New Zealand north of S. lat. 43°, Lord Howe Id. Norfolk Id.

Gnaphalium luteo-album, Linn.
Coastal cliffs and shingle beach.
All warm and temperate regions.

Sonchus oleraceus, Linn.
Near Gannets.
Cosmopolitan.

EXPLANATION OF THE PLATES.

Plate 2.

Fig. 1. White Island; the crater-lake.
Fig. 2. Gannets, with *Metrosideros* scrub in the middle distance.

Plate 3.

Interior of *Metrosideros* scrub.

A New Natural Family of Flowering Plants—Tristichaceæ.

By J. C. WILLIS, M.A., Sc.D., Director of the Botanic Gardens, Rio de Janeiro.

[Read 7th May, 1914.]

HAVING during the last few months been occupied with the Podostemaceæ of Brazil, I have begun to find that these plants are in reality as little known as those of India and Ceylon, which I have described in detail in previous monographs *. Already four absolutely new species have been discovered, some of them with morphological features of great interest, some of them combining existing genera, some apparently representing new genera. The results of this work will provide the material for several papers, of which this is the first.

The existing family Podostemaceæ contains many plants which are not in reality very closely related. The most aberrant of these—*Hydrostachys*, has already, and very properly, been removed by Warming, and placed in a special family, Hydrostachydaceæ; but the remainder of the family still exhibits two great divisions, which are perhaps more widely separated one from the other than the divisions in any other family of the flowering plants. These divisions are the Chlamydatæ and the Achlamydatæ, whose characters may be briefly summed up as follows:—

Chlamydatæ. Flower regular, or slightly irregular in the andrœcium. Perianth 3 or 5-merous, free or united, sepaloid, marcescent. Stamens 3 or 5, or 20–25, or 2, or 1. Ovary, 3–2 loc. Leaves small, simple, entire or nearly so, exstipulate.

Achlamydatæ. Flower regular, or slightly or highly zygomorphic, naked, enclosed in a spathe springing from the base of the stalk. Stamens ∞–1, sometimes monadelphous, usually with as many staminodes. Ovary, 2 loc. Leaves often large and much branched, usually stipulate.

This division has long appeared to me unsatisfactory. There are families with great gaps between their sub-orders, but none, or very few, in which it is not possible to conceive of fairly easy steps by which the transition from one to the other might be effected, and within a family this should always, it seems to me, be reasonably possible.

Now this is exactly what is impossible with the two groups into which the existing family of Podostemaceæ is divided. How can one pass easily

* Willis: "A Revision of the Podostemaceæ ot India and Ceylon," Ann. R. B. G. Peradeniya, vol. i. 1902, p. 181.

"Studies in the Morphology and Ecology of the Podostemaceæ of Ceylon and India." *L. c.* p. 257.

from the comparatively simple forms of the Chlamydatæ to the highly complex forms of the Achlamydatæ? How pass, for example, from the simple flower of Chlamydatæ with a monochlamydeous perianth and no spathe, to the achlamydeous flower with a spathe at the base of the stalk which occurs in the other group? How pass from a flower with one whorl of stamens and no staminodes to a flower with indefinite stamens, sometimes in more than one whorl, and as many staminodes? How pass from the small, simple, entire, moss-like leaf of the Chlamydatæ to the large, much branched, and highly complicated leaf of the other group? How pass from an exstipulate leaf to a stipulate one with the very complex formation of branches in the "axil" of a second and lower stipule? How pass from the simple stem thalli of Chlamydatæ to the highly complex stem thalli that occur in the Achlamydatæ? And so on, to other minor distinctions.

On the mere ground of the impossibility of passing easily from one group to the other, therefore, it seems to be necessary to divide the existing family of Podostemaceæ (Hydrostachydaceæ being supposed already removed) into two. I propose to give to the group Chlamydatæ the name TRISTICHACEÆ, from *Tristicha*, the genus first named in this group, and to reserve the name PODOSTEMACEÆ for the remainder of the family, at present included in the sub-order Achlamydatæ. The former group will include the genera *Tristicha*, *Lawia*, and *Weddellina*, the latter the rest of the old family.

Both families have practically the same geographical distribution. They occupy, in fact, the whole remaining part of the tropical and subtropical zone of the supposed ancient continent of Brazilia-Ethiopia, which had an arm running up through Madagascar to Ceylon and Peninsular India. The Tristichaceæ are practically confined to this region, while the Podostemaceæ go slightly beyond it into Java, Assam, and the United States. We shall return in a later paper to the subject of distribution of this group.

The two families thus constituted agree in many characters, but not sufficiently, it seems to me, to justify their being united. Both are herbs of rapidly moving water, attached to rocks by creeping roots (exceptions), on which are borne secondary shoots of the most various size and form. Their flowers appear above the water (exceptions). They have thick and fleshy placentas, on which are borne numerous, anatropous, horizontal ovules (exceptions). The fruit is a septifragal capsule (exceptions), and there is no style (exceptions). The seeds are exalbuminous, and the embryology is peculiar, and much the same in both families.

Placing the families, then, for the present in Rosales, near to the Saxifragaceæ (though I am by no means sure that this is the proper place), they occupy a separate sub-group, Podostemonineæ, for which Engler gives the following characters: submerged annual plants, flowering at the fall of the water, only resembling the Saxifragaceæ in the placenta; completely transformed by adaptation to peculiar conditions of life.

The characters of the two families may then be given briefly as follows :—

TRISTICHACEÆ. Perianth 3–5-merous, regular, free or united, sepaloid, marcescent. Stamens 3, 5, 20–25, or 2, or 1, usually alternate with perianth. Ovary 2–3-locular with ∞ anatropous ovules. Capsule stalked, septifragal, ribbed, with equal lobes and ∞ seeds. Herbs with numerous large secondary shoots from the creeping roots (except *Lawia*, which has the primary shoot flattened into a creeping thallus), bearing delicate, minute, simple exstipulate leaves.

PODOSTEMACEÆ. Flower achlamydeous, enclosed before opening in a spathe springing from the base of the stalk, regular or irregular. Stamens ∞ or few or 1, in a whorl, or on lower side of flower only, free or united, with usually as many staminodes. Ovary 2–1-locular, with ∞ or few anatropous ovules. Capsule stalked or sessile, ribbed or smooth, septifragal or indehiscent, with ∞ or few seeds. Herbs with creeping roots of great variety of form, bearing secondary shoots also of great diversity of form. Leaves usually large, much branched and complicated, stipulate, the branches arising under special lower stipules.

To consider in greater detail some of the points of difference :—

(1) Perianth.—Spathe and staminodes. In the first place, are these staminodes? It would seem that they are, for this reason. When a flower becomes zygomorphic, there seems no tendency for the upper part of the perianth to disappear, with rare exceptions, while the upper stamens often do so, and most often, perhaps, leave no staminodes as traces. Now here, the upper stamens disappear, and with them the upper organs of which we are speaking. Hence it would at any rate appear probable that these are really staminodes. And staminodes do not appear in the other family, nor, except to some extent in *Weddellina*, do numerous stamens, which are so often found in the Podostemaceæ proper.

The perianth then disappears, and is replaced by the spathe, but it is very difficult to regard this as homologous with it, for it shows no sign of being composed of any definite leaves, and it arises at the base and not the apex of the stalk, except in one African species*. In any case, the transition from one to the other state is very great.

(2) Few stamens (except sometimes *Weddellina*).—Many stamens and staminodes. This transition would be easy, were the many stamens in the Tristichaceæ, which are on the whole the more primitive, but it is more difficult to go the other way, for the flower tends on the whole to become simpler with greater complexity and adaptation of the vegetative organs.

* A new species of *Tristicha* which I have just discovered has two leaves at the base of the flower-stalk which may well represent the origin of the spathe, but otherwise it is tristichous, whereas the Podostemaceæ proper are distichous. I do not think that this discovery affects the real separation of these families.

(3) Simple moss-like leaf.—Complex compound leaf. There are in the Podostemaceæ simpler unbranched leaves, as for example in all the Indian forms, and in a few South American forms, but even so, these leaves, with their sheathing bases, and with the peculiar mode of (stem) branching that obtains are closely allied to, and must probably be considered derived from, the more complex leaves of the family. It is extraordinarily difficult to derive the one type of leaf from the other. Even if we suppose the ramuli or short shoots to be the precursors of the compound leaves of Podostemaceæ, the gap between the two families is a very large one, and there is no evidence that such could be the case, nor is there any parallel case in the vegetable kingdom.

(4) Exstipulate leaf.—Stipulate leaf. This is also a difficult change to make even between the most closely similar leaves of the two families, for the exstipulate Podostemaceæ of India are probably derived from the stipulate members of the same family, their leaves agreeing in their sheathing bases and in other ways, and the plants that possess them being highly modified, and having the peculiar branching.

(5) Simple branching.—Branching in the "axil" of a lower stipule. This also is a point in which there is a very wide gap between the two families, with apparently no intermediate stages.

(6) Secondary shoots simple, or slightly thalloid, with leaves on the upper side as well as on the margins.—Secondary shoots complex, with leaves only on the margins. Another point in which no intermediate stages occur, and in which it is almost impossible to derive one from the other.

Practically it comes to this, that almost the only thing the two families have in common in the morphology of the vegetative organs is the origin of the shoots from creeping roots.

There are also many minor details in which the Podostemaceæ differ from the Tristichaceæ, but the above seem amply sufficient to warrant the separation, even if the criterion of an order be that of Bentham and Hooker, rather than that of Engler and Prantl.

The only form that shows any signs of closer relationship to the Podostemaceæ among the Tristichaceæ is *Weddellina*, but this is only in a very few points, such as more numerous stamens and a bicarpellary ovary.

Finally, we may give the detailed characters of the two new families, as separated.

TRISTICHACEÆ. Flower ⚥, fully hypogynous, small, inconspicuous, regular, or slightly irregular by absence of one or two stamens, monochlamydeous, without spathe. Perianth 3–5-merous, free or united, equalling or exceeding the ovary, imbricate, sepaloid, marcescent. Stamens as many as perianth, or 4–5 times as many (*Weddellina*), or reduced to 2 or 1, usually alternate with the perianth; anthers bilocular, introrse; pollen simple.

Ovary superior, ellipsoid, of 2–3 carpels, 2–3-locular, with thick central placenta, delicate septa, and ∞ anatropous, horizontal, ascending ovules: stigmas usually sessile, as many as carpels (style in *Weddellina*). Capsule stalked, ribbed (usually conspicuously), septifragal, with equal lobes usually persistent upon the pedicel after dehiscence. Cortex of pedicel and capsule usually deciduous. Seeds ∞, small, exalbuminous, with straight embryo, mucilaginous if wetted.

Herbs living on rocks in rapidly moving water, usually annual, but persisting if not exposed to the air, flowering with the fall of the water-level in the drier season, germinating with the rise of the water. Roots filamentous, creeping over the rock, branching freely, attached by root-hairs and haptera, and giving rise to endogenous secondary shoots at frequent intervals (*Lawia* has no roots, the thalloid shoot being the primary axis). Secondary shoots long, much branched, or flattened into thalli. Branches often of two kinds, one normal, the other ramuli or shoots of limited growth, sometimes with tristichous leaves. Leaves small, delicate, moss-like, simple, usually entire, exstipulate. Flowers terminal, sometimes on special shoots.

The family includes the following genera and species:

Tristicha hypnoides.	Mexico to Uruguay; Africa trop.	*fide* Warming.
„ *alternifolia.*	Africa trop., Madagascar.	
„ sp. nov.	S. Brazil.	
„ *ramosissima.*	S.W. India.	
Lawia zeylanica.	W. India, Ceylon.	
Weddellina squamulosa.	Guiana, North Brazil.	

PODOSTEMACEÆ. Flower ⚥, fully hypogynous, small or fairly large, inconspicuous or brightly coloured, regular, slightly irregular, or highly zygomorphic, achlamydeous, enclosed before anthesis in a closed spathe springing from the base of the stalk, and opening at the tip or along the upper side. Stamens ∞–1, in one or more whorls, free or united in one or more groups, regular or only on the lower side of the flower, usually with as many staminodes; pollen often didymous in zygomorphic flowers. Ovary superior, ellipsoid, of two carpels, 2–1-locular, symmetrical or zygomorphic (often highly so), with thick central placenta and ∞ or few (2–10) anatropous ovules, usually horizontal and more or less ascending; stigmas usually as many as carpels. Capsule stalked or sessile, ribbed or smooth, dehiscent or indehiscent, with equal or unequal lobes. Cortex of stalk and capsule often deciduous. Seeds ∞ or few, exalbuminous, with straight embryo. Testa becoming mucilaginous when wetted.

Herbs growing on rocks in rapid water, usually annual, but persisting if not exposed to the air, flowering with the fall of the water, germinating with the rise. Primary axis (? always) short, usually non-floriferous, giving

rise to adventitious roots which creep over the rock, attached by hairs and haptera. Roots of great variety of form, filamentous, ribbon-like, flattened and lichen-like, cup-like, &c., sometimes with drifting portion as well as creeping. Secondary shoots borne on the roots, endogenously, of great variety of forms, sometimes mere tufts of leaves, sometimes large thalloid bodies, or of other forms, with terminal flowers, often in sympodia. Leaves usually distichous, often large, compound or simple, usually much branched, often hairy above, usually sheathing and stipulate, with lateral branch borne under a second and lower stipule. Axis often elongating to bear the flowers, the leaves enlarging at the base to form bracts, the tips falling off.

Includes the other genera of existing Podostemaceæ (except *Hydrostachys*).

Notes on the Morphology of certain Structures concerned in Reproduction in the Genus *Gnetum*. By H. H. W. PEARSON, Sc.D., F.L.S., Henry Bolus Professor of Botany in the South African College *. (Abstract.)

[Read 4th June, 1914.]

THE author records the occurrence of complete ovules with 3, and occasionally 4, envelopes on the lower nodes of spikes of *Gnetum Gnemon* bearing male flowers, and adds that true androgynous as well as pseudo-androgynous spikes occur in *G. Gnemon*, and probably in other species. Four types of spike are known, which constitute a sequence ranging from the strictly unisexual to the bisexual form. Wettstein's opinion that evolution progressed from unisexual inflorescences towards a combined type is criticised, and the author favours Strasburger's conclusion that the existing types are the result of reduction from a primitive hermaphrodite type. The morphology of the 4 envelopes present in some ovules is discussed: the middle of the normal 3 integuments is believed to be duplicated, the outermost of the four being homologous with the outermost in the usual type. The presence of a bud subtended by the outermost envelope reveals a tendency towards the development of axillary structures by which the spike of *Gnetum* might arise by proliferation from a primitive inflorescence (or flower) bearing a single terminal ovule. The presence of a bud in the axil of the outer member supports the view that the flower-envelope of the Gnetales has been formed by the specialisation of a barren leaf-structure.

Certain stages, hitherto unrecorded, in the development of the male flower of *Gnetum Gnemon* are described: its antherophore is interpreted as foliar and as having been formed by the fusion of two filaments.

The author proceeds to discuss the origin and morphology of the endosperm: he gives an account of our knowledge of the tissue within the megaspore in the different genera of the Gnetales, and describes the structure of the megaspore in *Gnetum africanum*. At an early stage there is a differentiation into a fertile micropylar region and a sterile chalazal region as in *Welwitschia*: the cytoplasm in the lower half of the megaspore is blocked out into compartments, and the septation presents many resemblances to the condition described in *Welwitschia*. Each compartment contains more than one nucleus, usually five or more. There is no septation in the micropylar region. The nuclei in each compartment in the chalazal region fuse as in *Welwitschia*, while the nucellar "pavement tissue" described by

* Percy Sladen Memorial Expeditions in South-West Africa. (Assisted by Grants from the Royal Society.)

Coulter in *Gnetum Gnemon* also occurs in *G. africanum*: the latter species also shows prefertilization antipodal tissue in the megaspore like that described by Lotsy in *Gnetum Gnemon*, but the existence of which has been denied by Coulter. A comparison of *Gnetum* and *Welwitschia* leads to the statement that the primary endosperms of these two genera are in all respects homologous. In an earlier paper the author expressed the opinion that the endosperm of *Welwitschia* is not a true prothallus, but a new structure to be regarded as a definite morphological entity, neither sporophytic nor gametophytic, which he designated the trophophyte; it was further suggested that the endosperm of the Angiosperms may be a highly specialised form of this trophophyte. The objections raised by Lotsy and other authors to these views are fully examined, and evidence is brought forward in support of the original contention. The fact that a trophophyte occurs in *Gnetum* as well as in *Welwitschia* enhances its morphological importance, and the generally accepted opinion that *Gnetum* and *Welwitschia* are nearer to the Angiosperms than any other Gymnosperms, gives force to the contention that the peculiar endosperm of the Angiosperms had its origin in a nutritive tissue not essentially different from that in the megaspores of *Gnetum* and *Welwitschia*. Coulter's view that there is no necessary phylogenetic significance in its nuclear fusion in the embryo-sac of an Angiosperm is also discussed. If the fusion of nuclei possesses no morphological significance, the phylogeny of the nuclei which fuse is still to be determined. Among the very diverse views that have been entertained, the possibility that the polar nuclei of Angiosperms may be morphologically, as well as functionally, the representatives of the fusing nuclei of *Welwitschia* and *Gnetum* has perhaps received too little attention.

Ecological Notes ; chiefly Cryptogamic.

By the late WILLIAM WEST, F.L.S.

[Read 18th June, 1914.]

AT a meeting of the Botanical Section of the British Association at Cambridge in 1904, after the reading of several ecological papers, Professor A. Engler commented on the paucity or almost total absence of any ecological work with regard to cryptogams, and to my mind his remarks were justified, as whatever observations had already been made, little had been published, and that by few workers. Since then very little ecological work has been published on the cellular plants of the British Isles compared with that concerning the vascular ones, if we except a few recent papers.

When one sets out with open eyes in a good district far away from the influence of the smoke of towns or cities, one is at once struck by the wealth of the cryptogamic flora, especially if the place is in the montane zone, and far more so if in the alpine. The richness is moreover intensified if the sea is near, and more so still on the Western coast, on account of the Atlantic influence and the abundant rainfall. Supposing one enters a montane wood in spring, one finds the rocks and stones covered with cellular cryptogams, the tree-trunks are also often partially or almost entirely covered, and usually where parts of them at first seem bare, these portions generally reveal on closer inspection a more or less complete covering of crustaceous lichens. Even the soil between the abutting rocks often shows a greater wealth of cellular than of vascular plants. If one turns out of the wood and examines a hilly pasture, its most conspicuous feature is often its richness in mosses, but when examined at a later period when the vascular plants are at their best, the mosses are usually overlooked. If one then examines the walls, a mass of cellular cryptogams is again met with as the most conspicuous feature.

The best time for noting the cellular cryptogamic undergrowth in woods and that on the branches of the trees is in spring before the buds unfold. By examining the branches blown off the trees during storms, and also those of felled trees, the associations on the upper branches can be readily ascertained. Much of it escapes one's vision if the examination takes place in summer or autumn, when the leaves are on the trees and the herbaceous vascular plants are in full vigour.

The following associations are selected from a large number I have noted during the last three or four decades.

A glance at the corticole associations of trees will serve as a beginning but many more observations will be required before these associations can

approach anything like exhaustion. A large number of trees have been examined in various parts of the British Isles, away from the pernicious influence of smoke. The results will be seen to be varied, the variation being due to different kinds of exposure, the different age of the trees, their aggregation or complete or partial isolation, the amount of rainfall, the proximity of mountains or sea, as well as other factors. *Stereodon cupressiformis* var. *filiformis* is generally the most prevalent corticolous moss, yet in some districts with a heavy rainfall, as parts of Kerry, Argyll, Cumberland, &c., *Isothecium myosuroides* becomes the most abundant epiphyte, and it is often quite dominant on the lower part of the trunks, when it hardly or does not at all extend above. When the trees are subject to a drive of wind from the mountains with much rain, as at Capel Curig, *Lecanora tartarea* is sometimes a dominant epiphyte, with *Platysma glaucum* often as a subdominant. As a general rule *Parmelia saxatilis* is the most abundant epiphytic lichen.

The following rough percentage records will illustrate the point further, and especially as showing much variability, so much so at times, without very apparent cause, that one wonders whether the prevalence of one or another kind is not sometimes due to the earlier time of the arrival of the successful epiphyte on the unoccupied places.

Corticolous Associations (chiefly).

Observations in Scotland.

Inverary. Average rainfall, 83 inches; average of total days of rain, 225.

The approximate percentage of sub-bareness * on 15 Beeches (see p. 59) was 16, the average percentage of epiphytes 84, made up thus:—*Stereodon cupressiformis* (35), *Frullania dilatata* (2), *Parmelia saxatilis* (4), *Pertusaria* spp. (6⅓), *Ricasolia amplissima* (2⅓), *R. lætevirens* (4), *Lobaria monaria* (8), crustaceous lichens (8⅓).

Stereodon resupinatus, *Graphis scripta*, *Evernia Prunastri*, *Ramalina farinacea*, *R. fastigiata*, *Stictina fuliginosa*, and a few other lichens occurred on these beeches in small quantity. *Polypodium vulgare* was also a frequent epiphyte. Sometimes *Mnium hornum* crept up the trunks for a short distance from the ground. The lichens were mostly on the exposed sides, the bryophytes on the less exposed ones.

* The term sub-bareness always includes variable quantities of small scattered patches of crustaceous lichens such as *Lecanora subfusca*, *Lecidea parasema*, *Graphis* spp., &c.

15 *lots of old Beeches* from 180 to above 200 centimetres in diameter, with rather different degrees of exposure (see p. 58).

Name of epiphyte.	No. 1.	2.	3.	4.	5.	6.	7.	Further in the wood. 8.	9.	More exposed. 10.	11.	12.	In deeper shade. 13.	14.	Only about 65 cms. in diameter. 15.
Stereodon cupressiformis, var. *filiformis*	25 *	Reaching up to at least 13 metres. 75	30	Mostly on the more shaded side. 15	6	10	70	5	75	40	Chiefly on shadier side. 15	20	Chiefly on shadier side. 45	5	90
Isothecium myosuroides	Mostly at base. 10	Around base for 50 centimetres. 5	Dominant at base up to 65 cms. 10	Mostly at base. 5	Chiefly about base. 5	Up to 125 cms. on one side of base. 12	For 65 cms. at base. 5	80	10	For 50 cms. at base. 5	For 70 cms. at base. 10	For 50 cms. at base. 5	On N. & E. chiefly. 45		Mostly at base. 5
Neckera pennata	......	......	......	......	......	......	A little.	......	5						
Neckera complanata	......	......	......	......	......	......	......	......	...	......	......	......	......	5	
Camptothecium sericeum	......	......	......	......	......	......	......	......	...	......	......	......	5		
Frullania dilatata	......	3	......	......	4	......	......			5	2	5	......	10	
Frullania Tamarisci	......	......	......	4	......	4	A little.								
Metzgeria furcata	A little.	......	......	......	8	3	......	......	..	......	2				
Lobaria pulmonaria	......	4	25	Chiefly on the most exposed side. 20	5	......	5	......	5	8	20	15	......	15	
Parmelia saxatilis	2	3	25	......	15	5	3	......	...	7					
Ricasolia lætevirens	......	......	......	On mostly exposed side. 10	12	5	6	......	...	......	6	5	......	10	5
Ricasolia amplissima with *Dendriscocaulon bolacinum*	......	......	......	Chiefly on most exposed side. 25	......	......	6	......	...	......	......	5			
Pertusaria communis, *P. faginea*, and *P. multipuncta*	9	8	......	4	10	8	3	......	...	......	......	5	......	15	
Pertusaria globulifera, *P. Wulfeni*, and *P. velata*	11	......	......	......	......	7	......	......	...	......	A little.	......	......	15	
Crustaceous lichens such as *Lecidea parasema*, *Lecanora subfusca*, &c.	......	......	......	......	25	30	......	......	...	30	40				
Coccocarpia plumbea	......	......	......	......	......	......	......	... ..	...	......	......	......	......	5	
Parmelia sulcata	5	2	......	......	5										
Parmelia fuliginosa, var. *lætevirens*	......	......	......	3	......	......	......	......	...	......	......	......	Chiefly on shadier side. 20		
Parmelia perlata	5	......	......	4	5	......	......	......	...	......	......	......	10		
Parmelia cetrarioides	5														
Sub-bareness	About 20	Practically none.	About 10	About 10	About 5	About 10	Practically none.	Very little.	On S. side. 5	About 5	About 5	About 5	5	20	Practically none.

* The numbers in the tables represent the approximate percentage areas of the trunks.

8 *lots of old Beeches* near the village, from 180 to over 200 centimetres in diameter (see p. 61).

Name of epiphyte.	No. 1.	2.	3.	4.	5.	6.	7.	8.	
Stereodon cupressiformis, var. *filiformis*	40	80	40	40	95	50	50	30	=53 per cent. about.
Pertusaria globulifera	20	5	10	......	A little.	5	6	3	=8 per cent. about.
Pertusaria faginea	......	3	4						
Pertusaria Wulfeni	5	6	8	......	......	5			
Pertusaria multipuncta	......	......	......	......	......	5	......	7	
Parmelia saxatilis	5	3	8	15	A little.	10	......	5	=6 per cent. about.
Parmelia perlata	......	2	......	......	......	3			
Parmelia lævigata	......	......	......	......	......	......	......	5	
Parmelia fuliginosa, var. *lætevirens*	......	......	......	......	......	20	......	5	
Lobaria pulmonaria	......	......	......	10	......	......	4	5	
Ricasolia amplissima	......	......	......	......	......	......	6		
Ricasolia lætevirens	......	......	......	......	......	......	6		
Frullania dilatata	......	......	5	......	A little.				
Metzgeria furcata	......	......	......	......	......	......	5		
Isothecium myosuroides	......	Very little at base.	A little at base.	......	At base all round for 80 cms. A little above with *Stereodon.*	About base for 30 cms.	About base for 60 cms.	A little at base.	The percentage of this is not reckoned in this table.
Sub-bareness (with a few crustaceous lichens)	30	Very little.	About 25	About 30	Hardly any.	Hardly any.	A little.	About 33	=15 per cent. about.

There was no *Parmelia physodes* or *Platysma glaucum* on any of these trees. On the more exposed trunks some specimens of *Ricasolia amplissima* were measured 150×90 centimetres, and some of *R. lætevirens* 120×90 centimetres. On the lower part of some trunks, epiphytic on *Stereodon cupressiformis*, *Pertusaria globulifera* occurred measuring as much as 90×120 centimetres.

Small quantities of the following also occurred on these trees:—*Evernia Prunastri*, *Ramalina fastigiata*, *Collema nigrescens*, *Usnea ceratina*, *U. hirta* (sparingly), *Coccocarpia plumbea*, *Stereodon resupinatus*, with a little *Mnium hornum* about the base now and then.

The undergrowth showing in August under these avenues of Beeches was a mixed association of old *Anthoxanthum odoratum*, *Holcus mollis*, *Agrostis alba*, a little *Ranunculus repens*, seedlings of *Fagus*, patches of *Isothecium myosuroides*, *Polytrichum formosum*, smaller quantities of *Hylocomium loreum*, and *Mnium hornum* now and then.

Some other Beeches of the same age, nearer the village (see p. 60), were more sheltered than those about a mile away, they were generally not so prolific in lichens. *Stereodon cupressiformis* var. *filiformis* was dominant on many of them, with patches of *Parmelia saxatilis* and *Pertusaria faginea*; others bore scattered over the *Stereodon*, plants of *Ramalina fastigiata*, *R. canaliculata*, *R. farinacea*, *Evernia Prunastri*, *Usnea ceratina*, and *U. hirta* in the higher parts, and small patches of *Cladonia cæspiticia* below. Others had quite 80 per cent. of the *Stereodon* with large patches of *Pertusaria globulifera* towards the base. Others were covered completely with *Parmelia saxatilis* (35), *Pertusaria globulifera* (30), *Stereodon cupressiformis* var. *filiformis* (10 to 15), *Evernia Prunastri*, *Usnea ceratina*, and species of *Ramalina* (about 20). Others were covered up to 90 centimetres from the base with *Isothecium myosuroides*, and above that a few had *Metzgeria furcata* quite dominant over all other species. Others showed *Isothecium myosuroides* as the chief epiphyte (90); the little islands where it did not occur were occupied chiefly by *Graphis elegans*. There was much variation in the epiphytic vegetation of these Beeches without any apparent cause. Specimens of *Parmelia fuliginosa* var. *lætevirens* were measured 180 centimetres broad. In some places *Armillaria mucidus* was in fine condition on these old Beeches.

The most abundant and almost only epiphytes on some Hollies were *Graphis elegans*, its var. *serpentina*, and *Opegrapha atra*.

6 lots of Ashes and 5 lots of Oaks near Inverary (see p. 63).

Name of epiphyte.	Ashes.						Oaks.				
	No. 1.	2.	3.	4.	5.	6.	About 50 cms. in diameter. 1.	In a wood. 2.	In shade. 3.	About 25 cms. in diameter. 4.	At some distance from others. 5.
Isothecium myosuroides	All round up to 3 metres high, then on N. side. 60	Chiefly at base. 15	30	40	About 45 cms. in diameter. At base only. 6	40 cms. in diameter. A third of of it at base. 20	10	On E. N. & W. sides chiefly. 45	12	Chiefly in lower part. 35	
Stereodon cupressiformis, var. *filiformis*	Only on upper part. 6	5	......	......	60	30	45	......	25	Chiefly on upper part. 35	65
Frullania dilatata	......	5	Mostly on S. side. 20	......	......	......	35	......	6		
Frullania Tamarisci	10	......	......	......	Mostly in upper part. 10	......	......	......	......	Creeping over the moss. 5	
Metzgeria furcata	......	......	......	......	......	......	......	......	......	Often creeping over the moss. 5	
Neckera complanata	......	10									
Zygodon viridissimus	......	10	......	......	......	......	......	......	All on S. side. 20		
Pertusaria globulifera	......	......	Mostly on S. side. 15	......	......	......	......	5	6		
Ricasolia lætevirens	......	......	3	40	......	......	......	......	4		
Lecanora tartarea	......	......	......	......	......	......	......	15			
Lobaria pulmonaria	......	......	......	......	......	......	......	15			
Parmelia sulcata	......	......	......	......	......	......	......	......	......	......	15
Thelotrema lepadinum	......	......	......	......	3	8					
Coccocarpia plumbea	......	5	A little.								
Pannaria rubiginosa	......	5									
Sub-bareness	The rest.	The rest.	The rest.	The rest.	The rest.	The rest.	The rest.	The rest.	The rest.	The rest.	The rest.

Scattered among the Ashes and Oaks (see p. 62) smaller quantities of *Leptogium Burgesii*, *Graphis scripta*, and *Cladonia pyxidata* occurred.

The average approximate percentages of the most frequent of the above epiphytes were:—*Isothecium myosuroides*, 28 on Ash, 20 on Oak, 25 on both; *Stereodon cupressiformis*, 17 on Ash, 34 on Oak, 24½ on both; *Frullania dilatata*, 4 on Ash, 8 on Oak, 6 on both; *Ricasolia lætevirens*, 7 on Ash, 4 on both. The large subhorizontal branches of the larger Oaks were almost completely covered with a mixed association of *Parmelia saxatilis*, *P. fuliginosa* var. *lætevirens*, *P. perlata*, *Platysma glaucum*, *Usnea ceratina*, *Lecidea parasema*, *Ramalina fastigiata*, *Frullania dilatata*, *Weissia ulophylla*, and a little *Neckera pumila* (on the underside). The branches of the younger Oaks were more than half covered with an association of *Platysma glaucum*, *Usnea ceratina*, and *Stereodon cupressiformis* chiefly.

The undergrowth of the stony soil here consisted of scattered patches of *Pteris*, *Blechnum*, *Stereodon cupressiformis*, *Mnium hornum*, *M. undulatum*, *Plagiochila spinulosa*, &c.

On some Sycamores about 60 centimetres in diameter, *Neckera complanata* was the chief plant bearing sporophytes. *Lobaria pulmonaria*, *Ricasolia lætevirens*, and *Metzgeria furctata* were scattered in fair quantity, *Ricasolia amplissima* occurred more sparingly here and there, while *Isothecium myosuroides* usually surrounded the base. Other Sycamores in another part bore:—*Isothecium mysosuroides* (65), *Stereodon cupressiformis* (20), *Metzgeria furcata* (5), *Thelotrema lepadinum* (2), and sub-bareness the rest. Another place gave:—*Lobaria pulmonaria* (50), *Lobarina scrobiculata* (10), *Frullania Tamarisci* (8), *Metzgeria furcata* (2), *Pertusaria communis* (2), *Stereodon cupressiformis* (5), *Isothecium myosuroides* about the base up to 70 centimetres, the rest sub-bareness. Some younger Sycamores about 35 to 40 centimetres in diameter had:—*Lobaria pulmonaria* (10), *Metzgeria furcata* well mixed with *Neckera complanata* (20), *Frullania dilatata* (3), *Pertusaria communis* (2), *Isothecium myosuroides*, chiefly in lower part (40), the rest sub-bareness.

Some large and rather exposed Pines had about their base: *Stereodon cupressiformis*, and scattered in crevices much *Cladonia digitata*, with a bright yellow barren *Calicium* (probably *hyperellum*) scattered profusely over the bark.

Some Rowans bore *Stereodon cupressiformis* (70), *Isothecium myosuroides* for 30 centimetres about the base, the rest sub-bareness.

Some Hollies near had very little moss, *Stereodon cupressiformis* (3), *Thelotrema lepadinum* (20), *Graphis scripta* (5), the rest bareness.

Some Birches, high up in the wood, often subject to driving mists and rains from moorland, varied considerably in their epiphytes; the following represent averages of three lots:—A. *Lecanora tartarea* (30), *Parmelia*

Near St. Catherine's, opposite Inverary.—Various lots of trees (see p. 65).

Name of epiphyte.	Birches.	*Picea excelsa.*	Young about 30 cm. in diameter. *Pinus sylvestris.*	Oaks.						Ashes.	Sycamores.			
				A.	B.	C.	D.	E.	F.		A.	B.	C.	D.
Stereodon cupressiformis, var. *filiformis*.	10	5	5	10	Mostly about base. 5	30	40	25	25	5	3	...	A little.	
Weissia ulophylla (& *W. Bruchii*)......	...	...	...	A little.	...	...	3							
Weissia phyllantha	...	...	...	...	...	...	...	...	...	2	On side facing the shore 5	...	12	8
Orthotrichum spp.	...	...	...	...	...	...	...	...	...	3	...	...	...	5
Orthotrichum Lyellii......................	...	...	...	...	...	...	...	...	...	...	...	...	...	5
Parmelia saxatilis.........................	75 to 80	85	30	40	10	8	30	...	20	Only on some. 5	55	70	40	8
Parmelia physodes.........................	...	...	3											
Parmelia fuliginosa, var. *lætevirens* ...	...	...	2	10	30	6	5	...	...	...	...	8	...	5
Parmelia perlata	...	...	The scales of bark are soon thrown off these young Pines.	...	2	...	4	10	...	12	...	5	10	6
Lobarina scrobiculata	...	...		...	...	...	...	10						
Lobaria Pulmonaria.......................	...	...		...	...	...	...	...	20	20	...	...	...	5
Pertusaria globulifera	...	...		...	...	...	...	...	5					
Nephronium lusitanicum	...	...		...	...	...	...	...	...	8				
Frullania dilatata.........................	...	...		...	...	A little.	...	...	...	5	2	5	12	8 or 10
Frullania Tamarisci	...	...		...	...	...	...	6						
Sub-bareness..................................	10 to 15	Practically none up to 6 or 7 metres.	60	About 40	About 50	About 55	About 15	About 50	30	About 40 to 45	About 35	About 12	About 12	About 50

lævigata (10), the rest was a scattered formation of the following, chiefly: *Dicranum scoparium, Stereodon cupressiformis, Scapania gracilis, Usnea ceratina, Platysma glaucum,* and *Cladonia fimbriata,* with *Hylocomium parietinum* and *H. proliferum* all about the basal part. B. *Parmelia saxatilis* (50), *Stereodon cupressiformis* (10), *Usnea* (about 2 or 3), the rest sub-bareness. C. Almost covered with a mixed formation, the first few named being the most abundant: *Dicranum scoparium, Stereodon cupressiformis, Parmelia perlata, P. saxatilis* var. *furfuracea, Platysma glaucum, Frullania dilatata, Usnea ceratina,* and *Cladonia pyxidata,* with *Mnium hornum* creeping from the ground for about 30 centimetres about the base.

Near St. Catherine's, opposite Inverary (see p. 64).

No statistics of rainfall were obtainable from here, but it is probably about the same as that of Inverary.

In smaller quantity on the trees mentioned in the table were *Ramalina fastigiata, R. farinacea, Evernia Prunastri, Lecidea parasema, Usnea ceratina, Lecanora subfusca, Pertusaria leioplaca,* and *Isothecium myosuroides* about the base of some for about 40 centimetres.

The greatest luxuriance was shown on that side exposed towards Loch Fyne. The average approximate percentages of the most frequent of the above epiphytes were:—34 of *Parmelia saxatilis* on all, 43 on Sycamore, 18 on Oak; $11\frac{1}{2}$ of *Stereodon cupressiforme* on all, $4\frac{1}{3}$ of *Parmelia fuliginosa* var. *lætevirens* on all.

Some young Beeches showed considerable bareness, mosses were quite absent, the lichens present were the common species of *Lecidea, Lecanora,* and *Verrucaria.* A number of young Pines about 30 centimetres in diameter were nearly bare, except for a little *Stereodon cupressiformis* near the base and scattered plants of *Parmelia saxatilis* and *P. physodes* up to about $2\frac{1}{2}$ metres from the base, on some the *P. saxatilis* was quite absent. Stumps of felled trees were mostly covered with *Isothecium myosuroides.*

Some Alders had *Parmelia fuliginosa* var. *lætevirens* (about 5) with a few scattered patches of *Weissia ulophylla* and the commoner crustaceous lichens.

Some Elms showed variability in their epiphytes, one lot averaged:—*Stereodon cupressiformis* (30), *Parmelia perlata* (10), *P. saxatilis* (5), *Weissia ulophylla* (4), *Orthotrichum Lyellii* (4), and a little *Stictina fuliginosa.* Another lot showed:—*Parmelia saxatilis* (20), *P. perlata* (10), *Frullania dilatata* (10), *Stereodon cupressiformis,* near the base (3), *Pertusaria globulifera* (5), with a little *Camptothecium sericeum* and *Orthotrichum* spp.

Near Lamlash, Isle of Arran.

Average rainfall for Brodick (a few miles off) 68 inches; average of total days of rain, 207 (see p. 68).

Name of epiphyte.	Sycamores showing much variability under fairly similar conditions.								Exposed Ashes.	Ashes on roadside.	Exposed Oaks.	Other lots of Ashes.		
Stereodon cupressiformis, var. *filiformis*	20	...	20	10	20	Well shaded. 40	5	35	...	20	5	20	5	10
Stereodon resupinatus	5	45	10											
Weissia phyllantha	8	8	...	...	10	8	...	15	6	The amount of this on different trees varied much, it sometimes covered a square metre.				
Weissia ulophylla (with some *W. Bruchii*)	...	...	...	...	...	...	...	...	...	...	...	10	5	
Orthotrichum Lyellii	...	...	...	6	...	...	...	A little.	...	...	...	12		
Frullania dilatata	15	10	...	5	...	20	10	7	5	12	...	20	30	
Radula complanata	...	...	3	...	...	...	...	3						
Metzgeria furcata	...	...	5											
Parmelia saxatilis	...	...	...	...	...	...	...	...	40	...	60 to 65	...	...	10
Parmelia perlata	...	5	...	...	...	...	...	...	...	20				
Parmelia fuliginosa, var. *lætevirens*	...	...	...	...	...	...	...	...	12	...	...	...	...	20
Parmelia lævigata	...	...	...	...	...	...	...	...	..	...	5	...	...	5
Pertusaria globulifera	...	...	...	...	...	...	...	...	...	12				
Lecanora subfusca	10 to 15	5	...	...	...	10	12	...	2	...	...	5		
Lecidea parasema	...	A little.	...	...	...	...	5	...	3	...	...	5		
Pertusaria communis	...	5												
Opegrapha vulgata	...	...	5	...	10	...	A little.							
Opegrapha betulina	...	...	5											
Sub-bareness	45 to 50	About 20	About 50	Above 70	60	20	About 65	About 40	About 30	About 40	About 25	About 25	About 60	About 50

Sets of Alders in Monamore Glen, near Lamlash,
showing much variability of the epiphytes both in quantity and species (see p. 68).

Name of epiphyte.	*a.*	*b.*	*c.*	*d.*	*e.*	*f.*	*g.*	Lower down the glen. *h.*	High up the glen. *i.*	Much exposed. *k.*	One old tree erect but dead.
Stereodon cupressiformis, var. *filiformis*	50	This only for 2½ metres from base. 50 to 60	25	3	25	Only near base. 5	5	60	Mostly towards base. 10	...	On lower part. 20
Parmelia fuliginosa, var. *lætevirens*	...	10	15	45	15	40 to 50	35 to 40	...	5		
Parmelia perlata	...	...	...	...	...	...	...	...	...	5	
Parmelia saxatilis	...	7	...	35	...	35 to 40	50	10	60	25 to 40	
Parmelia physodes	...	...	...	...	...	...	...	Some of these bore the rupestral moss, *Glyphomitrum polyphyllum*, which was common on adjacent rocks.	5	25 to 40	
Parmelia lævigata	...	3	5	...	10	...	...		...	Sometimes more *P. physodes* than *P. saxatilis*.	
Platysma glaucum	...	...	...	5	..	...	...		...		80
Evernia Prunastri	...	...	A little.	2	...	A little.	A little.	Scattered tufts.	...	5	

Near Lamlash, Isle of Arran (see p. 66).

The average approximate percentages of the most frequent of the epiphytes given on p. 66 were:—*Stereodon cupressiformis*, 19 on Sycamore, 11 on Ash, 15 on all the species of trees. *Frullania dilatata*, 8 on Sycamore, 13 on Ash, 9½ on all.

Epiphytes in smaller quantities were scattered on the above trees, as:—*Cladonia pyxidata*, *Graphis scripta*, *Evernia Prunastri*, *Acrocardia gemmata*, *Ramalina farinacea*, *Opegrapha atra* var. *denigrata*, *Calicium* (barren), and *Camptothecium sericeum*.

Some other Sycamores bore only *Parmelia saxatilis* and *P. fuliginosa* var. *lætevirens* worth noting (10 to 15), the rest was sub-bare. Others bore a mixed association of *Pertusaria faginea*, *Opegrapha vulgata*, *Radula complanata*, *Weissia phyllantha*, and *Bryum capillare* (abundantly).

Some Ashes about 60 centimetres in diameter, growing in shade, had about 5 to 8 per cent. of *Collema nigrescens*, with a few crustaceous lichens and practically no bryophytes. *Opegrapha atra* var. *arthonoidea* occurred on Rowans.

Sets of Alders in Monamore Glen, near Lamlash (see p. 67).

Small quantities of the following also occurred on these:—*Usnea ceratina*, *Lecidea parasema*, *Lecanora parella*, *Calicium* (imperfect), *Cladonia macilenta*, and *Zygodon conoideus*.

The average approximate percentages of the three chief epiphytes on above were:—*Stereodon cupressiformis* 29, *Parmelia saxatilis* 23, *P. fuliginosa* var. *lætevirens* 17¼.

Some other Alders in shade bore a fair amount of *Cladonia macilenta*, a little *C. cæspiticia*, together with *Leproloma lanuginosum*, and large tufts of *Dicranum scoparium*; and others whose trunks were much inclined had a good clothing of *Polytrichum formosum* and *Polypodium vulgare*. Some of these old Alders often had three or four branches from one to two metres from the ground, varying from 30 to 40 centimetres in diameter.

The undergrowth (in August) in this Alder wood was a scattered association, varying much with extra wet or drier conditions. In the former places, *Juncus acutiflorus* was abundant with *Spiræa*, *Ulmaria*, and *Salix aurita*; in the latter places *Pteris* was abundant here and there; the other chief plants, under varying conditions, were *Blechnum Spicant*, *Rubus saxatilis*, *Lastræa Oreopteris*, *Athyrium Filix-fœmina*, *Carduus palustris*, *Prunella vulgaris*, *Mnium hornum*, and *Stereodon cupressiformis*, with *Pellia epiphylla* and *Amblystegium filicinum* about the tiny rills. Among the above smaller quantities of the following occurred:—*Oxalis*, *Ranunculus acris*, *R. repens*, *Anthoxanthum*, and *Potentilla erecta*.

Eight lots of Ashes in varied situations, near Lamlash.

Name of epiphyte.	a.	b.	c.	d.	About 45 cms. in diameter. e.	Near bank of stream. f.	g.	Near bank of stream. h.
Stereodon cupressiformis, var. *filiformis*.	12	10	Mostly near base. 10	Mostly in lower part. 25	Mostly below. 10	Mostly on side near stream. 25	...	Chiefly in lower part. 30 to 40
Stereodon resupinatus	8							
Weissia phyllantha	10	3	...	...	...	10		
Frullania dilatata	10	...	...	...	15	Mostly on side away from stream. 25	3	
Radula complanata	3	...	...	...	...	...	10	
Pertusaria sp. (barren)	...	...	...	8				
Pertusaria faginea	...	...	5					
Parmelia fuliginosa, var. *lætevirens* ...	...	20						
Parmelia perlata	...	...	...	...	...	...	10	
Parmelia lævigata	...	...	10	6	...	...	...	3
Parmelia sulcata	...	...	7					
Parmelia saxatilis	...	5	8					
Lecanora subfusca	...	5	3	...	3	...	...	5
Lecidea parasema	3	2	A little.	...	2	...	...	5
Evernia Prunastri	...	...	10					
Cladonia fimbriata	...	...	...	3	...	6		
Cladonia pyxidata	...	...	...	3	...	4		
Sub-bareness	About 50	About 55	About 45	About 55	About 65	About 30	About 75	45 to 55

Average approximate percentages of the two chief epiphytes: *Stereodon cupressiformis* 16, *Frullania dilatata* 6½.

Near Corrie, Isle of Arran (see p. 70).

In smaller quantity on some of the Ashes and Birches, the following also occurred :—*Stereodon resupinatus*, *Weissia ulophylla*, *W. Bruchii*, *Orthotrichum Lyellii*, *Zygodon viridissimus*, *Ramalina farinacea*, *Lecidea parasema*, *Plagiochila punctata*, and *P. asplenioides*.

The average approximate percentages of the three chief epiphytes on the above were :—*Stereodon cupressiformis*, 24 on Ash, 10 on Birch, 16½ average of both; *Parmelia fuliginosa* var. *lætevirens*, 15 on Ash, 10 on Birch, 12½ average of both ; *Parmelia saxatilis*, 13½ on Ash, 30 on Birch, 22½ average of both.

Near Corrie, Isle of Arran.

No data for rainfall were available, but it is probably about the same as that of Brodick, a few miles away (see p. 69).

Name of epiphyte.	Ashes. Not far from sea. *a.*	Ashes. Not far from sea. *b.*	Ashes. *c.*	Ashes. *d.*	Ashes. *e.*	Ashes. *f.*	Birches. *a.*	Birches. *b.*	Birches. Much exposed. *c.*	Birches. *d.*	Birches. *e.*	Birches. 40 cm. in diameter. *f.*	Birches. 30 cm. in diameter. *g.*
Stereodon cupressiformis, var. *filiformis*.	10	8	5	60	25	35	30	...	Near the base. 5	Mostly in lower part. 25	Near the base. 5	5	3
Frullania dilatata	...	...	5	...	5								
Frullania Tamarisci	...	...	3	3	2	5							
Parmelia saxatilis	20	Mostly in lower part. 40	12	3	2	5	...	5	30	20	30	60	65
Parmelia physodes	...	...	...	...	...	...	...	...	30	...	5		
Parmelia fuliginosa, var. *lætevirens* ...	30 to 35	15	25	5	3	10	...	10	...	10	20	2	6
Parmelia caperata	Towards base. 5												
Parmelia perlata	5 to 10	...	5	2	3								
Pertusaria faginea	...	...	5	...	2								
Pertusaria globulifera	...	...	5	...	...	3							
Evernia Prunastri	...	2	...	...	...	...	...	...	2	5	3	...	A little.
Cladonia pyxidata	...	...	...	...	...	...	3	...	3				
Dicranum scoparium	...	...	...	...	...	...	On lower part. 7	...	A little.				
Sub-bareness........................	About 5	About 30	About 30	About 25	About 55	About 40	About 60	About 85	About 30	About 40	About 35	About 30	About 25

Trees near Corrie (see p. 72).

	Alders.						Sycamores.		*Pinus sylvestris.*	Rowan.	Hazel.		Birches.		
	a.	*b.*	*c.*	*d.*	*e.*	*f.*	*a.*	*b.*			*a.*	*b.*	*a.*	*b.*	*c.*
					Not far from shore.						25 to 30 cms. in diam.		Glen Sannox.	Sannox to Ranza. Near base.	
Stereodon cupressiformis, var. *filiformis*	...	10	2 Mostly below	30	5	...	...	...	...	35	15	10	10	5	10
Dicranum scoparium	...	...	3												
Frullania dilatata	...	...	...	...	...	...	...	...	...	...	10	...	5		
Parmelia saxatilis	30	25	10	30	15	...	5	55	...	5	...	...	30	20	5 of type. 10
Parmelia caperata	...	Often creeping over *P. saxatilis.* 20	7	...	60	This almost covered the trunk. 70									
Parmelia fuliginosa, var. *lætevirens*	30	...	3	...	...	...	30	15	5	35	5	...	8	2	10
Parmelia physodes	...	...	...	...	...	...	...	...	...	...	...	...	12	20	
Parmelia perlata	...	...	40	A little.											
Platysma glaucum	...	...	...	...	...	...	...	...	...	...	...	...	...	3	
Lecidea parasema	...	...	...	...	...	...	3	...	...	...	5				
Lecanora subfusca	...	...	...	...	...	...	2	...	5	...	5				
Opegrapha atra	...	...	...	...	...	...	...	...	...	var. *arthonoidea.* A little.	3 varieties. 5	3			
Sub-bareness	40	45	35	About 40	About 20	About 30	About 60	About 30	About 90	About 25	About 50	About 85	About 35	About 50	About 65

Trees near Corrie (see p. 71).

The following also occurred in smaller quantity on the trees:—*Zygodon conoideus, Plagiochila punctata, Cladonia fimbriata, Pertusaria faginea,* on Alders; *Orthotrichum Lyellii* on Sycamores; *Arthropyrenia epidermidis* on Rowans; *Acrocordia biformis, Weissia ulophylla, Opegrapha herpetica, O. varia,* on Hazels; *Evernia Prunastri* and *Weissia ulophylla* on Birches.

Average approximate percentages of the three chief epiphytes of the above 15 lots:—*Stereodon cupressiformis* $8\frac{4}{3}$, *Parmelia saxatilis* $15\frac{2}{3}$, *Parmelia fuliginosa* var. *lætevirens* $9\frac{1}{2}$.

The relative percentages of trees in a small mixed wood near Corrie were:—Hazel 41, Birch 31, Ash 20, Rowan 4, Oak 2, Hawthorn 2. Alders only occurred in the lowest and flattest part, where they were preponderant.

Near Brodick, Lower Glen Rosa (see p. 73).

A few other species occurred in small quantity, such as *Cladonia fimbriata* var. *tubæformis, C. fibula, Pertusaria leioplaca, Usnea ceratina, Parmelia lævigata, Hylocomium brevirostre,* and *Weissia ulophylla.*

Average approximate percentages of the four chief epiphytes of the above 9 lots:—*Stereodon cupressiformis* 21, *Parmelia saxatilis* $18\frac{1}{3}$, *P. physodes* 5, *P. perlata* 5.

In a Larch wood, *Parmelia physodes* (about 40) was almost the only epiphyte, dwarf bits of *Usnea* occurred with it; they were chiefly on the windward side. There was a little *Platysma glaucum* on some of them, and scattered *Alectoria jubata* on others. Near the base of a few was *Cladonia squamosa*; *Parmelia saxatilis* and *Stereodon cupressiformis* were almost absent, and *Isothecium myosuroides* was quite absent. Wherever the branches were dead, they were covered with *Parmelia physodes.*

Some Oaks off the head of Holy Loch, Argyll (average rainfall 81 inches, average rainy days 222), on a slope about 8 metres from a rill, were practically covered with the following, the first being decidedly dominant: *Stereodon cupressiformis* var. *filiformis* (55), *Dicranum scoparium* (6), *Platysma glaucum* (10), *Evernia Prunastri* (8), *Parmelia physodes* (8), *P. saxatilis* (8), *Cladonia pyxidata* and *fimbriata* (3). *Isothecium myosuroides, Orthotricha,* and *Ulotæ* were absent on both these and the next.

Other Oaks at a little distance in a more exposed situation: *Stereodon cupressiformis* var. *filiformis* (45) was again dominant, it was more abundant on the leeward side; the rest consisted of:—*Parmelia saxatilis* (15), *P. physodes* (12), *Pertusaria globulifera* (10), *Evernia Prunastri* (6), *Cladonia fimbriata* and *squamosa* (2), with tufts of *Dicranum scoparium* and bits of *Usnea.*

Near Brodick, Lower Glen Rosa (see p. 72).

Name of epiphyte.	In shade.	More exposed.	Exposed.	On exposed slope.	Moderately shaded.	More exposed.	More exposed still.	More elevated.	In shade.
	Horse-Chestnuts.		Pines.	Limes.	Oaks. About 50 centimetres in diameter.				
Stereodon cupressiformis, var. *filiformis*	Mostly on N. side and towards mountain. 45	5	Mostly near base. 5	Mostly below and on N. side. 20	Chiefly towards base. 20	Near base. 5	15	Base covered up to 2½ metres. 45	30
Weissia phyllantha	...	3	...	...	...	A little.	...	A little.	
Frullania dilatata	...	5	...	...	...	5	3		
Frullania Tamarisci	...	...	...	...	...	...	...	20	
Parmelia saxatilis	Mostly on N. side towards sea. 35	Mostly on windward side. 60	20	25	...	A little.	20 Mostly on side towards mountain.	...	5
Parmelia physodes	...	...	20	5	...	...	20 On sheltered side mostly.		
Parmelia perlata	...	...	A little.	5	5	20	15		
Parmelia fuliginosa, var. *lætevirens*	...	5	...	15	...	10	2		
Cladonia spp. (mixed)	...	...	...	...	...	...	...	...	15
Ramalina farinacea	...	...	...	A little.	...	A little.	3		
Pertusaria lutescens ?	...	...	...	...	...	10			
Pertusaria globulifera	...	...	...	...	10				
Sub-bareness	About 20	About 20	About 50	About 30	About 65	About 55	About 20	About 35	About 40

In the upper part of Glen Coe, under Ben Atta (average rainfall 82 inches, 216 rainy days on an average), lower down the glen, an old solitary weather-beaten storm-pollarded holly, above 90 centimetres in diameter at 100 centimetres from the ground, was examined: it bore two branches 45 centimetres in diameter. It was fairly well clothed (for a holly) with a mixed association of *Dicranum scoparium*, *Stereodon compressiformis*, var., *Grimmia hypnoides*, *Parmelia physodes*, *P. saxatilis*, *P. perlata*, *Lecanora tartarea*, *Platysma glaucum*, *Cladonia cervicornis*, *Psoroma hypnorum*, *Pertusaria communis*, and *Sphærophoron coralloides* in smaller quantity, with tufts of two other species of *Cladonia*.

In a wood near Loch Awe, towards the Pass of Brander (rainfall about 82 inches, rainy days about 237), some Oaks about 45 to 50 centimetres in diameter bore:—*Stereodon cupressiformis* var. *filiformis* (45), *Frullania dilatata* (30)—mostly on windward side, *Lobaria pulmonaria* (5), *Pertusaria globulifera* (2), *Isothecium myosuroides* (5), with smaller quantities of *Lecanora tartarea*, *Cladonia squamosa*, and a little *Mnium hornum* about the base. Some of the high branches of these, which had been blown off during a gale, were about one-third covered with *Stereodon cupressiformis* var. *filiformis* (25), *Parmelia saxatilis* (4), *P. perlata*, *Usnea ceratina*, and *Weissia ulophylla* (3).

Another lot of Oaks about 30 centimetres in diameter had *Frullania dilatata* as the chief epiphyte on the lower 3 metres, with *Stereodon cupressiformis* var. *filiformis* as the chief one in all the upper part. Many younger Oaks were examined which showed a considerable amount of sub-bareness, with scattered patches of crustaceous lichens, as *Lecidea parasema*, *Pertusaria Wulfenii*, *Opegrapha atra*, &c., but the most conspicuous epiphyte was *Frullania dilatata*; scattered tufts of *Weissia ulophylla* and *W. Bruchii* were present, and all round the base was a varying mixture of *Isothecium myosuroides* and *Stereodon cupressiformis*.

Some Birches about 45 centimetres in diameter were only sparsely covered with epiphytes. *Stereodon cupressiformis* was chiefly on the leeward side, and there were scattered tufts of *Dicranum scoparium* and patches of *Frullania dilatata*, with *Cladonia digitata* and *Mnium hornum* about the base.

Some Alders a little lower down the slope were about half covered with a mixture of the following, the first being the most abundant:—*Stereodon cupressiformis* var. (especially on the leeward side), *Parmelia sulcata*, and scattered patches of *Frullania dilatata*, *Weissia ulophylla*, *W. Bruchii*, *Parmelia perlata*, *P. fuliginosa* var. *lætevirens*, *Pertusaria Wulfeni*, *Lecidea parasema*, and *Dicranum scoparium*, the latter chiefly in the lower part.

The old stumps of a number of trees were completely covered with the following chiefly:—*Stereodon cupressiformis*, the type (50), *Hylocomium proliferum* (25), *Thuidium tamariscinum* (25), and a few tufts of various species of *Cladonia*.

Further on towards the outlet of the Loch, many of the trees bore a great abundance of large specimens of *Ricasolia amplissima* with its attendant *Dendriscocaulon bolacinum*, and a still greater quantity of *Ricasolia lætevirens* occurred also on the trunks, but the former was most abundant in the more exposed situations, facing seawards. I have noticed this elsewhere, as in Cantyre, Moidart, &c. A number of trees on the eastern side of the Loch were practically covered with *Stereodon cupressiformis* var. *filiformis* with sporophytes in abundance, and creeping over it in very large patches were *Lobaria Pulmonaria* with abundant apothecia and *Lobarina scrobiculata*.

Some Ash trees, about 60 centimetres in diameter, were examined in Glen Falloch; they were found to vary considerably, under apparently similar conditions. One set averaged: *Isothecium myosuroides* (25), mostly towards base, *Stereodon cupressiformis* var. *filiformis* (20), *Metzgeria furcata* (6), *Stictina limbata* and *S. fuliginosa* (4), *Cladonia squamosa* (2), the rest sub-bareness. Another set had:—*Stereodon cupressiformis* var. *filiformis* (20), *Metzgeria furcata* (30), mostly on shadiest side, *Frullania Tamarisci* (20); the latter seemed to have taken the place of the *Isothecium* though it was not near the base, the *Stereodon* clothing that part.

Observations in Ireland.

At Muckross, Kerry (rainfall about 64 inches, rainy days about 225), near the side of the road, some Elms and Limes which were some distance apart were examined; the moss which almost covered the windward side was *Camptothecium sericeum*; associated with it were *Frullania dilatata*, *Collema flaccidum*, *Acrocordia gemmata*, and a small *Leptogium* on the moss.

In the woods adjoining, the species of trees varied much in different parts, as many have been planted. Some of the more natural portions examined consisted of Oak, Birch, and Holly, with some Rowan, Crab, and Arbutus. Honeysuckle and Ivy were frequent. The Oaks in this part were well covered with *Isothecium myosuroides* (60), *Ricasolia lætevirens* (5), *Thuidium tamariscinum* (2), with a little *Stictina limbata* and *Dicranum scoparium*, the rest was sub-bareness. Other Oaks nearer the large lake, subject to the direct drive of the wind from the hills, had a different epiphytic flora, *Lobaria pulmonaria* was abundant with plenty of *Pannaria rubiginosa* and its variety *cæruleo-badia*. *Coccocarpia plumbea* was much less abundant. *Stereodon cupressiformis* var. and *Metzgeria furcata* also occurred among the lichens. Where there was a fair amount of wind-drive in another part of the wood, the Oaks were covered all round the base with *Eurhynchium myosuroides*, and bore further up *Lobaria pulmonaria* (30), *Metzgeria furcata* (5), *Stereodon cupressiformis* (5), *Pannaria rubiginosa* (2), the rest sub-bareness. The Beeches were well clothed with a very varied association of the following chiefly, some of the species, first one and then another, showing

dominance here and there:—*Parmelia saxatilis*, *P. fuliginosa* var. *lætevirens*, *Verrucaria nitida*, *Stereodon resupinatus*, *Metzgeria furcata*, *Frullania dilatata*, *Pertusaria communis*, *P. faginea*, *Lobaria pulmonaria*, *Lobarina scrobiculata*, *Lecidea parasema*, *Lecanora subfusca*, and *Nephronium lusitanicum*. On some Beeches the dominant epiphyte was *Parmelia caperata*. The following were the epiphytes on some Larches:—*Frullania dilatata* (20), *Parmelia perlata*, *Weissia ulophylla*, and *Evernia Prunastri* (5), *Stereodon cupressiformis* around the base to the height of 60 centimetres, the rest sub-bareness. The upper side of the branches was almost covered with an association of *Evernia Prunastri*, *Usnea ceratina*, *Frullania dilatata*, *Parmelia sulcata*, and scattered cushions of *Weissia ulophylla*. One of the striking features on exposed Oaks near Cromagloun, was the abundance of *Ricasolia lætevirens*, some of the larger examples of which measured 165 by 60 centimetres.

A number of various trees in a small park near Dingle (Kerry), not far from the sea, and somewhat exposed to a drive from it, were examined. *Weissia phyllantha* and *Parmelia perlata* were the chief epiphytes, the former averaging about 35, the latter about 25 to 30 per cent. *Pyrenula nitida* was also abundant, many trunks showed 20 per cent. of it, the remainder was about 10 per cent.: it consisted chiefly of *Frullania dilatata*, *Stereodon resupinatus*, and *Lecanora parella*.

Observations in Wales.

Eight lots of Oaks near Arthog (see p. 77).
Average rainfall about 65 inches; rainy days, 197.

Scattered amongst the Oaks, on some of the trunks, were small quantities of *Lobaria scrobiculata*, *Stictina fuliginosa*, *Usnea ceratina*, *Lecidea parasema*, *Cladonia fimbriata*, and *Metzgeria furcata*. In some cases *Mnium hornum* crept up from the ground around the base to 30 centimetres.

Average approximate percentages of the chief epiphytes on the above:—*Stereodon cupressiformis* var. 31, *Frullania dilatata* 8, *Parmelia saxatilis* 5, *Pertusaria globulifera* 4.

A number of young Oaks on the lower slope of a buttress of the mountain were examined; they were mostly from 25 to 35 centimetres in diameter; the chief plants were *Frullania dilatata* (10), *Stereodon cupressiformis* (2), *Isothecium myosuroides*, about the base chiefly (3), with a few scattered patches of *Weissia ulophylla* and *Lecidea parasema*. The Hazels bore an association of *Parmelia perlata*, *Frullania dilatata*, *Pyrenula nitida*, *Lecanora subfusca*, *Lecidea parasema*, *Pertusaria leioplaca*, and *Arthonia radiata*. Some Ashes near Penmaenpool, about 50 centimetres in diameter, had a very varied flora, the average consisted of:—*Isothecium myosuroides* (mostly at base) and *Frullania dilatata* (8), *Stereodon cupressiformis* var. *filiformis*, mostly on lower part (15), *Stictina fuliginosa*, *Evernia Prunastri*, *Usnea hirta*,

Eight lots of Oaks near Arthog (see p. 76).

Name of epiphyte.	Woods on hill-side. 1.	2.	3.	4.	Rather exposed to winds. 5.	6.	Towards Dolgelly. 7.	Near Penmaenpool. 8.
	About 50 centimetres in diameter.				45 to 50 cms. in diam.			
Stereodon cupressiformis, var. *filiformis*	70 All in the lower part.	25 Mostly below.	50 At very base.	30 Chiefly below.	...	...	6	70
Isothecium myosuroides	10	20	5	25	60	85	45	20
Frullania dilatata	...	Often creeping over *Isothecium*. 5	20	10	30	3	4	A little.
Parmelia saxatilis	...	...	...	...	10	4	25	A little.
Parmelia perlata	...	5	...	...	...	3	...	3
Parmelia caperata	Frequent on the branches.	...	...	...	...	...	3	2
Parmelia physodes	...	...	...	...	...	...	5	A little.
Parmelia fuliginosa, var. *lætevirens*	...	A little.	...	... Including other species.	...	3		
Pertusaria globulifera	...	15	2	10	...	...	...	A little.
Evernia Prunastri	...	...	2	...	A little.	2	3	A little.
Sub-bareness	20	25	20	25	60	85	45	20

Pertusaria faginea, and *Cladonia fimbriata* (5), *Parmelia physodes* (2), *P. saxatilis*, mostly in upper part (5), *P. perlata* (5), *P. fuliginosa* var. *lætevirens*, *P. caperata*, *Weissia ulophylla*, *Orthotrichum Lyellii* (5), the rest sub-bareness. Some other Ashes had a greater proportion of *Stereodon cupressiformis*, with absence of some of the other species, such as *Parmelia perlata*, *Stictina fuliginosa*, &c.

Five lots of Acer.

Name of epiphyte.	1. 130 cms. in diam.	2.	3.	4.	5.
		From 45 to 60 centimetres in diameter.			
Stereodon cupressiformis, var. *filiformis*	...	20	Mostly near the base. 25	Rather exposed. ...	Exposed mostly below 5
Isothecium myosuroides	...	...	Mostly at base. 5		
Frullania dilatata	2	3	20	A little.	2
Metzgeria furcata	60	...	2		
Lecidea parasema	A little.	...	A little.	24	2
Pertusaria communis	2	...	...	...	2
Parmelia perlata	...	2	A little.	A little.	A little.
Lecanora subfusca	...	A little.	A little.	10	2
Sub-bareness	About 35	About 75	About 45	About 60	About 45

Other species in smaller quantities among the above were:—*Weissia ulophylla*, *Stereodon resupinatus*, *Trentepohlia aurea*, *Lobaria pulmonaria*, *Parmelia caperata*, *P. physodes*, *Usnea ceratina*, *Graphis scripta*, and *Evernia Prunastri*.

Average approximate percentages of the chief epiphytes on the above:—*Stereodon cupressiformis* 10, *Metzgeria furcata* 12, *Lecidea parasema* 5, *Frullania dilatata* 5.

A number of Hollies from 30 to 35 centimetres in diameter showed:—*Stereodon cupressiformis* var. (10), *Parmelia fuliginosa* var. *lætevirens* (5), *P. caperata* (2), *Graphis elegans* and *G. scripta*, with the varieties *stellata* and *pulverulenta* of the latter (3), sub-bareness the rest.

The average of a number of Alders examined showed the following. The windward side bore fully a third more epiphytes than the leeward one, a mixed association of *Stereodon cupressiformis*, *Parmelia perlata*, with smaller quantities of *Usnea ceratina*, *Evernia Prunastri*, and *Trentepohlia*; sub-bareness held sway over two-thirds of the area.

A single very old Chestnut was examined, the main part of its trunk was almost covered with *Opegrapha varia* and *Stereodon resupinatus*, mixed with a little *Homalia trichomanoides*. A number of exposed Birches about 30 to 35 centimetres in diameter showed that *Parmelia saxatilis* was the dominant epiphyte (30), with *P. fuliginosa* var. *lætevirens* (10), a little *Evernia Prunastri*, an interlacing of *Isothecium myosuroides* and *Stereodon cupressiforme* mostly about the base (5), and sub-bareness (55).

Near Bettws-y-Coed, epiphytes on Oaks, Birches, and Sycamores (see p. 80). Average rainfall, 53 inches; average rainy days, 217.

Among the above were smaller quantities of *Lecanora subfusca, Cladonia fimbriata, C. pyxidata, Usnea ceratina, Graphis scripta, Dicranum scoparium*, and surrounding the base of some was *Leucobryum glaucum*, climbing up from the ground.

Average approximate percentages of the chief epiphytes on the above thirteen lots:—*Stereodon cupressiformis* 27, *Parmelia saxatilis* 10, *Lecanora tartarea* 8½, *Pertusaria* spp. 3½.

Some other Oaks in the same wood were quite covered up to three metres with but little else than *Stereodon cupressiformis*, and above that with the following lichens mixed with it, and in about the same proportions collectively as the moss:—*Parmelia saxatilis* (10), *P. fuliginosa* var. *lætevirens* (5), *Platysma glaucum* (5), *Evernia Prunastri* (2), *Calicium* sp. barren (a little), the rest being almost bare.

A number of trees had been blown down, their branches were examined; the epiphytes were:—*Parmelia saxatilis* (15), *P. physodes* (10), *P. fuliginosa* var. *lætevirens* (5), *Evernia Prunastri* (3), *Usnea ceratina* (3), *Pyrenula nitida* (3), and a few other crustaceous lichens; sub-bareness (about 50).

The undergrowth as seen in early June under the trees of this wood (Oak chiefly, with a few *Picea excelsa, Larix europæa*, &c.), was a varied association of *Lonicera Periclymenum, Teucrium Scorodonia, Pteris* (none at all in some places), *Rubus* sp., *Anemone nemorosa, Ranunculus Ficaria, Lastræa Filix-mas*, and *Endymion non-scriptum*. *Arum maculatum, Stellaria Holostea*, and *Hypericum pulchrum* were scarce, the *Endymion* was quite dominant here and there, and where rocks abutted, *Cotyledon Umbilicus* occurred. Between the above plants were masses of *Hylocomium triquetrum, Thuidium tamariscinum*, and *Polytrichum formosum*.

At a considerable distance from the last wood, in an exposed position on a slope, a number of trees of *Picea excelsa* had been recently felled: their branches were examined, *Parmelia physodes* was the dominant epiphyte, it almost completely covered them.

In the lower part of another wood, there was hardly any species of *Ulota* or *Orthotrichum* on the trees, and only fragmentary lichens, though the

Near Bettws-y-Coed (see p. 79).

Name of epiphyte.	Oaks averaging 60 centimetres in diameter.	Another lot of Oaks about 45 centimetres in diameter.	Another lot of Oaks 40 to 45 centimetres in diameter.	Other Oaks 45 to 50 centimetres in diameter.	Another lot of Oaks exposed to a strong wind-drive, 50 cms. average diameter.	Other Oaks at some distance from the last, about 45 centimetres in diameter.	Some other Oaks from 40 to 50 centimetres in diameter.	Birches about 40 centimetres in diameter.	Sycamores about 50 centimetres in diameter.	Some old Birches, about 50 centimetres in diameter, in another part of the wood.	Other Oaks very much exposed to wind.	Another lot of Oaks.	An old shrub of *Prunus spinosa*, partly dead.
Stereodon cupressiformis, var. *filiformis*	90	In upper part usually. 30	Mostly on leeward side. 60	Chiefly on N. and leeward side. 70	5 Covered at base for 30 cms.	10 All near the base.	20 Near base.	About the base and on N. side. 10 to 15	... Around the base up to 45 cms.	...	Mostly at base. 5	50	3
Isothecium myosuroides	A little at base.	...	...	...		5	4	...					
Frullania dilatata	2 to 6	..	..	Mostly in lower part. 5	3	...	...	...	...	...	...	5	
Frullania Tamarisci	...	...	...	...	...	30							
Weissia ulophylla	...	...	2	...	...	...	...	...	...	...	...	...	2
Orthotrichum Lyellii	...	...	2	...	...	...	...	...	...	...	...	...	
Parmelia saxatilis, var. *furfuracea*	...	...	..	...	50	...	10	10 to 15	10	3	25	15	10
Parmelia perlata	...	...	8	5	...	...	...	...	...	...	8	10	
Parmelia fuliginosa, var. *lætevirens*	...	...	...	...	5	...	...	5	...	...	3		
Parmelia caperata	...	...	...	...	...	...	...	..	...	2	2		
Parmelia physodes	...	...	...	...	...	...	...	5	...	...	...	...	30
Lecanora tartarea	...	...	...	...	...	10	20	...	...	70	10		
Pertusaria spp. (*multipuncta*, *faginea*, *communis* chiefly).	A little	6	2	8	Mostly on N. side. 10	...	8	...	...	...	5	5	
Evernia Prunastri	...	...	A little.	...	5	...	2	5 to 10	5	...	...	...	25
Usnea ceratina	...	...	...	...	...	...	3	3 to 5	...	6 to 8	...	...	10
Pannaria rubiginosa	...	...	...	...	...	...	...	...	Mostly on windward side. 35				
Sub-bareness	The rest.	The rest.	The rest.	The rest.	The rest.	The rest.	The rest.	The rest.	The rest.	The rest.	With some Ivy. The rest.	The rest.	The rest.

arboreal form of *Stereodon cupressiformis* was yet fairly frequent ; but in the same wood at some distance, where the ground was flat and somewhat marshy, the epiphytic lichens began to be frequent, clearly showing the influence of a more constantly moist atmosphere.

Many other Oaks were examined in another wood similar to the last, the trunks were less than half covered with epiphytes ; the chief one was *Stereodon cupressiformis* var., with scattered patches of *Frullania dilatata*, and scattered amongst these were small quantities of *Lecanora parella*, *Pertusaria leioplaca*, and *Lecidea parasema*. The trunks of the few Sycamores amongst the latter were barer than the Oaks, but were well clothed about their lower part with *Isothecium myosuroides* and *Stereodon cupressiformis*. At a higher zone in this wood a number of Oaks bore in their lower part *Stereodon cupressiformis* often mixed with *Mnium hornum*, higher up was a mixed association of *Dicranum scoparium*, *Frullania dilatata*, *Cladonia fimbriata*, *Parmelia physodes*, *P. saxatilis*, *Evernia Prunastri*, with several species of *Pertusaria* ; the dead branches were attacked by *Chlorosplenium æruginosum*.

Some Oaks and their branches, near Capel Curig.

Name of epiphyte.	1st lot of exposed Oaks.	2nd lot of exposed Oaks.	3rd lot of Oaks.	3 lots of blown-off branches of Oaks.		
Stereodon cupressiformis	5	8	10 Mostly below.			
Isothecium myosuroides	...	10	5	5		
Frullania Tamarisci	40	25				
Lecanora tartarea	40	35	...	20		
Parmelia lævigata	3	3	A little.			
Parmelia physodes	2	...	...	10	40	15
Parmelia saxatilis	...	...	2	30	10	10
Platysma glaucum	2	A little.	...	...	2	25
Evernia Prunastri	A little.	A little.	...	...	...	3
Sub-bareness	The rest.	The rest.	The rest.	The rest.	The rest.	The rest.

In addition to the above a little of the following was present :—*Cladonia fimbriata* and *Usnea ceratina*. The average approximate percentages of the chief species on the above (trunks and branches) were :—*Lecanora tartarea* 16, *Frullania Tamarisci* 11, *Isothecium myosuroides* 3, *Stereodon cupressiformis* 4, *Parmelia physodes* 11, *P. saxatilis* 9, *Platysma glaucum* 5.

Some other Oaks, much exposed to winds from the mountains, bore 35

to 40 per cent. of *Lecanora tartarea*, 25 to 40 per cent. of *Frullania Tamarisci*, about 5 per cent. of *Isothecium myosuroides*, and about 6 per cent. of *Stereodon cupressiformis*. Others not so much exposed showed about 20 per cent. of *Lecanora tartarea*, 30 per cent. of *Parmelia saxatilis*, and about 10 per cent. of *P. physodes*; the epiphytes were chiefly on the windward side.

Four lots of Birches from Capel Curig.

(The windward side was always richest.)

Name of epiphyte.	1.	2.	3.	4.	
Stereodon cupressiformis	...	...	5	4	
Dicranum scoparium	...	6			
Polytrichum formosum	...	4 Mostly on lower part.			
Scapania gracilis	...	10 Mostly below.			
Lecanora tartarea	20	40	30	50	=35 per cent.
Usnea ceratina	3	20	... A little *Evernia Prunastri* and *Usnea*.	A little.	= 6 per cent.
Cladonia macilenta, *C. pyxidata*, and *C. digitata*	3	5	5 Mostly above.	...	= 3 per cent.
Platysma glaucum	...	...	25	40	=16 per cent.
Parmelia physodes	...	...	2		
Parmelia saxatilis	...	... Creeping over the *Scapania*.	...	3	
Parmelia lævigata	3	2	...	2	
Pertusaria faginea	2	...	3		
Sphærophoron coralloides	10				
Sub-bareness	The rest.	The rest.	The rest.	The rest.	

The branches bore *Platysma glaucum* (30), *Usnea ceratina* (25), *Stereodon cupressiformis* (5), *Parmelia saxatilis* (10), *Lecanora tartarea* (2).

Climbing up some of these Birches to a height of about 30 centimetres was *Dicranum scoparium* mixed with *Hylocomium loreum*, *Polytrichum formosum*, and *Cladonia sylvatica*, a mixture similar to the vegetation of the ground. On various other trees (chiefly Oaks and Birches) at some distance from the last, the chief feature again was the abundance of *Lecanora tartarea* with fine apothecia where it faced the winds from the mountains;

some of these also bore dense cushions of *Sphærophoron coralloides*, with small patches of *Parmelia caperata*. About the base of these trees *Mylia Taylori*, *Sphagnum acutifolium*, and *Plagiothecium undulatum* occurred in profusion together with pulvinate masses of *Leucobryum glaucum*.

The chief plants on the Hazels examined were patches of *Frullania dilatata* and tufts of *Weissia ulophylla*.

Some exposed Pines, about 60 centimetres in diameter, bore *Parmelia saxatilis* (25), *P. physodes* (10), *Lecanora tartarea* (6), *Platysma glaucum* (3), *Dicranum scoparium* (2), *Evernia Prunastri* (2), *Stereodon cupressiformis* (2), sub-bareness (50).

A few young Alders (which were scarce) bore about 10 per cent. of a mixture of *Parmelia saxatilis*, *P. fuliginosa* var. *lætevirens*, *P. physodes*, and a few tufts of *Weissia ulophylla*.

Observations in the Lake District (Borrowdale) (see p. 84).

Rainfall (mean for 15 years) at Seathwaite 139·29 inches; at Keswick, 60·53 inches. The observations were made mostly between these two places.

The epiphytes were at their best in the more shaded sides.

Scattered amongst the Oaks were small quantities of *Pertusaria communis*, *Hypnum rutabulum*, *Leucodon sciuroides*, *Parmelia saxatilis*, *Lecanora subfusca*, *Collema nigrescens*, *Evernia Prunastri*, *Weissia ulophylla*, *W. Bruchii*, *Orthotrichum affine*, *O. stramineum*, *Cladonia macilenta*, *C. fibula*, *C. pyxidata*, and *C. fimbriata*. About the base of some, *Thuidium tamariscinum*, *Hylocomium umbratum*, and *H. loreum* also occurred.

The average approximate percentages of the chief epiphytes on the Ashes show:—*Stereodon cupressiformis* 50, *Frullania dilatata* 7, *Isothecium myosuroides* 6, *Camptothecium sericeum* 3, *Pertusaria globulifera* 2½.

The Hollies were the barest. The Birches examined were almost bare except towards and about the base, where the following occurred:—*Dicranum scoparium*, *Lepidozia reptans*, *Scapania nemorosa*, and *Sphærophoron coralloides*. The trunks of *Picea excelsa* were practically bare except for a little *Stereodon cupressiformis* near the base. On the Birches in the more exposed higher parts of the wood were scattered patches of *Parmelia saxatilis*, *P. sulcata*, *P. physodes* (very small), *Platysma glaucum*, *Usnea hirta*, *Cladonia fimbriata*, *Stereodon cupressiformis*, with *Isothecium myosuroides* around the base. On some adjoining Oaks there was abundance of *Lecanora tartarea*, but mostly barren.

A few observations were made W. of Ennerdale (Cumberland). Oaks there bore *Stereodon cupressiformis* (10), *Parmelia saxatilis* (5), *Cladonia* spp. (3), *Arthropyrenia analepta* (a little), sub-bareness (about 80). The Beeches were almost bare. Birches bore:—*Parmelia saxatilis* (10), *P. physodes* (5), *Evernia Prunastri* (a little), sub-bareness (about 85). The Sycamores examined were usually covered with *Stereodon cupressiformis* for about 40 to

6 lots of Oaks and 8 of Ashes in Borrowdale (see p. 83).

Name of epiphyte.	Oaks.	At edge of wood. Oaks.	Oaks.	Oaks.	Large solitary Oaks.	A solitary exposed Oak about 100 cms. in diameter.	8 lots of planted Ashes not forming a wood. 1.	2.	3.	4.	5.	6.	7.	8.
Stereodon cupressiformis, var. *filiformis*.	40	...	25 Mostly near base.	20	35	20	75	65	80	60	75	70	60	75
Isothecium myosuroides ...	...	20	25	40										
Camptothecium sericeum ...	...	20	20	...	...	...	...	...	2					
Neckera complanata	...	12												
Neckera pumila	5													
Metzgeria furcata	...	...	...	10	On windward side. 10									
Frullania dilatata	20	...	...	25	...	20	...	A little.	...	...	3	5	20	5
Orthotrichum Lyellii	...	...	...	...	...	...	...	...	...	One patch 60 × 30 cms. on E. side. 10				
Pertusaria globulifera	5	10	6	A little.	A little.	...	...	5	...	...	5	...	...	5
Pertusaria faginea	...	...	...	...	...	...	...	...	Mostly in lower part. 3	3	...	5		
Peltigera canina	...	5	12											
Parmelia saxatilis	...	..	...	A little.	A little.	...	...	...	...	8				
Parmelia fuliginosa, var. *lætevirens*	...	...	...	...	...	A little.	...	...	...	3				
Stictina limbata	...	3	2											
Arthonia Swartziana	...	...	...	...	...	15								
Polypodium vulgare	15	10												
Sub-bareness	The rest.	The rest.	The rest.	The rest.										

50 centimetres from the base, above that were :—*Parmelia physodes* (10), *P. saxatilis* (3), *Evernia Prunastri*, and *Opegrapha atra* (a little), sub-bareness (about 85). The Larches had hardly anything on them except scattered plants of *Parmelia physodes*, with a few small patches of *Cladonia* sp. near the base.

Some Pines in Wastdale about 70 years old, at about 75 metres elevation, were quite without mosses or hepaticæ ; *Parmelia physodes* was dominant (50 to 60), *P. saxatilis* (8), the rest was almost bare, with the exception of about 3 per cent. of a mixture of *P. caperata*, *Evernia furfuracea*, *E. Prunastri*, *Usnea ceratina*, and small patches of a *Cladonia*.

General Summary of foregoing Observations.

Summing up what can be chiefly gathered from the preceding tables, *Stereodon cupressiformis* var. *filiformis* (not in all cases the typical variety) is shown to be by far the most abundant epiphyte, *Parmelia saxatilis* coming next, often, but not always, the var. *furfuracea*. On subjecting the above tables to analysis, the percentage ratio (*inter se*) of the chief epiphytes comes out approximately as follows :—*Stereodon cupressiformis* 16, *Parmelia saxatilis* 6, *Isothecium myosuroides* 2, *Frullania dilatata* 2, *Parmelia fuliginosa* var. *lætevirens* 2, *Lecanora tartarea* 2, *Platysma glaucum* 1, *Pertusaria globulifera* with *P. faginea* and other species 1.

This summary is not by any means given as a decisive statement suitable to every district, or even for the average of several districts ; it represents approximately what was actually observed in those districts that were partly examined in some detail. Many uncommon epiphytes were noted which are not enumerated, as they only occurred either very locally or in very small quantity, the more frequent of them come under the category of "sub-bareness."

Frullania dilatata is sometimes a subdominant epiphyte. *Lobaria pulmonaria*, *Ricasolia lætevirens*, *Nephromium lusitanicum*, *Lobarina scrobiculata*, and some species of *Parmelia* and *Cladonia* often grow very extensively over the surface of *Stereodon cupressiformis*, as well as over the sub-bare bark. *Pyrenula nitida* sometimes almost covers young trees, especially those with a somewhat smooth bark. *Opegrapha atra* also often occupies considerable areas ; and *Graphis elegans* sometimes almost covers the Hollies. *Parmelia caperata* is here and there one of the chief epiphytes, especially near the sea. *P. physodes* in very exposed places, especially on Conifers, is sometimes the most abundant epiphyte. Now and then one finds *Parmelia perlata* or *P. fuliginosa* var. *lætevirens* to be the chief corticolous lichen. Other epiphytic lichens, which are occasionally found in fair abundance, have not been mentioned, but these are often local, requiring special conditions, such as *Alectoria jubata* in montane and subalpine valleys. *Metzgeria furcata* is here and there in great profusion as an epiphyte, often creeping over foliaceous lichens ; and in moister western woods *Radula complanata* is also sometimes a conspicuous epiphyte.

The Lichens of South Lancashire.

By J. A. Wheldon, F.L.S., and W. G. Travis.

[Read 18th March, 1915.]

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I. Introduction.

South Lancashire (Watson's (**23**) vice-county 59) comprises all that part of Lancashire which lies south of the River Ribble. Its area is about 1130 sq. miles. The vice-county presents considerable diversity in its physical features. The eastern and central portion is a hilly country which forms one of the western buttresses of the Pennine Range. In the valleys among the hills lie many of the cotton-manufacturing towns for which the county is famous, while high above them on the broad hill-tops are bleak, wet moorlands, frequently covered by cotton-grass (*Eriophorum* spp.), which flourishes on the deep peaty soil. The highest point in South Lancashire is Pendle Hill, 1831 ft., situated in the extreme N.E. corner of the area; the next highest is Boulsworth Hill (1700 ft.) on the Pennine watershed; and there are several other points on the moorland plateaux which lie 1500 ft. above sea-level. The low-lying coastal plain, which extends from the mouth of the River Ribble far up the Mersey valley, consists mainly of arable land; but here and there are the remains of peat-mosses, which were formerly of great extent but are now mostly reclaimed.

The soils and rocks are mainly siliceous in character ; but in that portion of the Ribble valley which comes within our area there is a tract, a few square miles in extent, of Carboniferous Limestone. On the northern flanks of Pendle Hill there is also a series of impure limestones and calcareous mudstones, known geologically as the Pendleside Series. Igneous or metamorphic rocks do not exist *in situ* in South Lancashire.

II. Adverse Conditions affecting the Lichen-Flora.

Deterioration of the Flora.—Its proximity to the ocean and the physical and climatic conditions of the vice-county are such as would, under normal circumstances, be favourable to a luxuriant growth of lichens. The whole flora of South Lancashire has, however, been so deleteriously influenced by certain factors due to enormous industrial developments, that we have to deal with a flora, and particularly a lichen-flora, which is quite abnormal from that which should exist under natural conditions.

We know there are other manufacturing districts in the country where the vegetation is badly affected by smoke, but we believe nowhere in the country does there exist an area equal in size to South Lancashire where the evil effects of atmospheric impurity are so widespread. We propose, therefore, to treat this aspect of our subject rather fully; and we shall then proceed to show exactly the nature of the deterioration which the lichen-flora of South Lancashire has undergone.

It is well known that no section of the flora is so much affected by man's interference as that which embraces the lichens. These plants are peculiarly sensitive to pollution of the atmosphere and streams; and the fact is that conditions inimical to lichen-growth have been so long prevalent in South Lancashire, that the whole facies of the original lichen-flora has been changed; and it is difficult from the vestiges which now remain to form an accurate conception of the lichen-flora as it was a hundred or even fifty years ago. It is only from a few records left by earlier workers, and from the gradual improvement of the flora as we travel northward into West Lancashire and Westmorland, that we can judge that lichens must formerly have been far more luxuriant and numerous than they are now. By a comparison with neighbouring districts of analogous physical and climatic character, we can form some conception of what the lichens of South Lancashire would be under normal circumstances, and must have been before Lancashire became a great manufacturing county.

Population and Industries.—The concentration of manufacturing industry and of population in South Lancashire is a remarkable feature. Thus, according to the 1911 census, the population of the county was 4,767,832, of which fully 4¼ millions reside in South Lancashire. To illustrate the vast increase in the population, consequent largely upon the enormous strides in industrial development which took place during the nineteenth century, it may be mentioned that the population of Lancashire in 1841 was 1,667,054, whilst in 1801 the inhabitants of the *whole county* only numbered 673,486. It was, then, during the nineteenth century, and particularly its latter half, that the whole fabric of modern industrial Lancashire was built up, whilst agriculture was relegated to a very subordinate position. With the great increase in population, the old

towns expanded enormously, and entirely new towns and urban districts sprang into being. This process still continues, and in all our urban districts there is a steady and rapid encroachment of the town on the open country.

Atmospheric Pollution.—It need hardly be said that the flora of a densely-populated district like South Lancashire has been deleteriously affected by human activities in many ways. With most of these we need not here concern ourselves, and we shall confine ourselves mainly to a consideration of the effects of atmospheric pollution on the flora, and more especially on the lichen-flora, since the pollution of the air by smoke and chemical fumes has more deleteriously affected cryptogamic plant-life in South Lancashire than any other agency.

The degree to which our air is polluted by smoke, and the effect of this atmospheric pollution on the vegetation, are not fully recognized. The average town-dweller thinks that when the suburbs are passed, and the open country reached, the air is pure and the vegetation quite unaffected by town-smoke. To the trained eye, however, the cryptogamic plants, and especially the mosses and lichens, tell their own tale. The condition of the lichens in any district is a sure indication of the relative purity of the air, since lichens, especially the corticole and rupestral species, are exceedingly intolerant of atmospheric impurity, and rapidly begin to deteriorate as soon as the atmosphere is smoke-polluted to such an extent that there is the slightest deposition of combustion-products upon them or upon the surfaces upon which they grow.

In some parts of our district fumes from chemical manufacture and ore-smelting play a not unimportant part in the pollution of the atmosphere; but generally in South Lancashire, as in other populous manufacturing areas, the chief cause of atmospheric impurity is the continual discharge into the air of the noxious products resulting from the consumption of bituminous coal, which is burnt more or less imperfectly in such enormous quantities in our domestic fires and in the furnaces of our factories. According to Prof. Lewes (**10** *b*), coal contains from 0·3 to 3·5 per cent. of sulphur, chiefly in the form of iron pyrites; and a result inseparable from the burning of coal is the liberation of sulphur dioxide (SO_2), which is ultimately oxidized in the atmosphere into sulphuric acid (H_2SO_4), and brought down in the rain. The sulphur compounds, such as sulphur dioxide and sulphuretted hydrogen, are the most harmful in their effect on vegetation of all the products of coal-combustion. Among the other noxious products emitted from our chimneys are unconsumed carbon and certain tarry and mineral matters, which together constitute what we know as soot. For details indicating the extent to which large industrial towns in the North of England are responsible for polluting the atmosphere, we may refer to the results obtained by the Manchester Air Analysis Committee (**13**) and to the investigations of

Cohen (**2**) and Ruston (**17**) at Leeds. A few figures may, however, be given here. It has been calculated that 35,000 tons of soot are poured into the atmosphere every year from the domestic chimneys alone of Manchester. Prof. Cohen has estimated the amount of soot emitted per annum from the factories of Leeds at 5000 tons, and from house-fires, 30,000 tons. Near to one of the chief industrial areas in Leeds, Mr. A. G. Ruston (**17**) found that fully 40 per cent. of the sunlight during the year of his investigation was shut off by the smoke in the atmosphere, and that the solid impurities which reached the ground as the result of coal-combustion amounted to the high figure of 1565 pounds per acre. As illustrating the relative amounts of sulphur acids in the air in various districts, we take from Macfie's (**12**) book some of the figures which he quotes from Angus Smith showing the amounts of sulphuric acid (sulphates) obtained by analysis of rainfall:—Valentia (Ireland) taken as 100, England (inland country places) 202·2, Waterloo (near Liverpool) 418·7, St. Helens 1215·8, Liverpool 1450·2, Manchester (average 1869–70) 1641·9, near an alkali-works (isolated) 2685.

Although the air is constantly renewed by movements of the atmosphere, and cleansed by rain and snow-fall, yet the discharge of impurities into the atmosphere is continuous, and the impurities are wafted about and deposited on every surface with which the air comes in contact. The solid impurities in coal-smoke are usually mostly deposited near the place of origin, and the amount of deposition falls off considerably outside the towns. In some parts of South Lancashire, however, the towns are so close together that in those areas a continuous smoke-zone is created. The solid impurities may be rapidly deposited near their place of origin, but the noxious gases are diffused over much wider areas; and there is not a square mile in the whole of South Lancashire, even in the parts most remote from towns, where the vegetation is not visibly affected by smoke. Mr. Albert Wilson (**25**) has shown that the smoke of South Lancashire and the West Riding of Yorkshire affects practically the whole of the North of England.

Under the conditions of atmospheric pollution which obtain in South Lancashire, we cannot be surprised that lichens, which of all plants are the most sensitive to atmospheric impurity, should be most seriously affected. A large number of lichens have their habitat on bare rocks and tree-trunks. In our district such surfaces are smoke-begrimed to such an extent that the growth of lichens and mosses on them is inhibited or greatly hindered. As pointed out by Wheldon and Wilson (**26 & 27**), the rain as it trickles down such tree-trunks or rock-surfaces becomes more and more charged with acid impurities as it descends, and these prove fatal to young and tender cryptogamic plant-growths. A film of soot on rock, bark, or other surfaces, apart from any other injurious character, also serves to mask the surface;

and this doubtless impedes the development of spores, for many lichens, particularly bark-loving species, often exhibit such marked selective preferences in regard to the nature of the substratum of their habitat, that they will only grow on the bark of certain kinds of trees.

III. Present State of the Lichen-Flora.

We think that these adverse conditions have now reached their maximum, and that a slight improvement has even begun to manifest itself. Increasing attention is being paid to the subject of smoke-abatement, and all the tendencies are towards an alleviation of the smoke-nuisance. The ever-growing use of gas and electricity for power, light, and heating, means a vast saving in coal-consumption, and a consequent reduction in the production of smoke. The adoption of mechanical-stokers and smoke-consuming furnaces in our factories, and, still more, the advent of the internal combustion-engine as a means of power-production, are big steps in the right direction. It is probable that domestic fires are now more responsible for the smoke-nuisance than the factory-furnace. It may be pointed out, however, that even if improved methods of coal-consumption were to effect the nearly total abolition of smoke aad soot, yet so long as coal is burnt at all, the production of sulphuric acid in the atmosphere is inevitable. All hope of improvement, therefore, lies in a diminution of the amount of coal consumed and the substitution of coal by other kinds of fuel. Any change in this respect is likely to be a slow one, particularly as regards domestic fires. It is probable, then, that a long time will elapse before the smoke-nuisance is totally abolished in a county like Lancashire ; but with evidence on every hand pointing to an alleviation of the evil in the future, we may confidently look forward to improved conditions: and that this improvement will continue, and even progress with greater rapidity as time goes on, is practically certain. To every improvement in the degree of atmospheric impurity the lichen-flora will respond step by step, until normal conditions are re-established.

With these anticipations of better things before us, we have now to deal with the lichens of South Lancashire as they are at present. Our paper will serve to depict the lichen-flora as it appeared when at its worst, and our Systematic List may be useful some day to compare with a regenerated flora, which will assuredly develop when the air becomes purer. With this in mind, our object is to draw as faithful a picture as we can of the present state of the lichen-flora, and to describe the peculiar conditions under which it now exists. This is necessary, since, without some explanation, the list which follows might be liable to mislead in several ways. It would hardly be comprehensible to lichenologists of the future working at a regenerated flora, and incapable of realizing the conditions which obtain at present. The absence of records of many common species might be attributed to our

having overlooked them, rather than to what is in most cases really the fact, that they do not at present exist in the area. To botanists in other parts of the country, our lengthy list, which embraces a number of rare, and even new, species, might, at first sight, seem hardly consistent with the existence of the unfavourable conditions we have referred to. As a matter of fact, our list is more remarkable for what it does not contain than for what it does. Quite a number of the species recorded have been found in a single locality only as the result of careful search ; and the greater proportion occurs in one or two specially favoured tracts situated as far from the great manufacturing centres as the limits of the vice-county permit. It must also be remembered that many of our lichens are depauperate and ill-developed to such an extent that they are frequently difficult to determine ; nevertheless, poor as they are, they help to swell out the list and tend to give the reader the impression that the lichen-flora is better than it really is.

A. *Condition of the various Classes of Lichens.*

Corticole Species.—It will be gathered from what has been already said, that it is the corticole lichens which have suffered most severely from the effects of atmospheric pollution; and in fact the most striking feature of our lichen-flora is the comparative rarity of corticole lichens. A glance through our list will show that whole genera of bark-loving lichens, such as *Calicium*, *Usnea*, *Ramalina*, *Graphis*, *Opegrapha*, *Arthonia*, &c., are either totally absent, or very poorly represented. The conditions of atmospheric impurity in South Lancashire are such that corticole lichens have been brought to the verge of extinction in the vice-county. In other parts of the British Isles which are little affected by smoke, corticole species form a large percentage of the lichen-flora ; in South Lancashire, however, exclusively corticole or lignicole lichens only form about 15 per cent. of the species now existing. In considering this figure, allowance must be made for the fact that many of the species reckoned in our estimate have only occurred on prostrate trunks and dead twigs lying on the ground.

Under normal conditions, the trunks of our older trees in open situations should be grey and shaggy with a growth of species of *Usnea*, *Ramalina*, *Pertusaria*, *Parmelia*, and *Evernia*, and any space left by the larger foliaceous lichens should be more or less occupied by crustaceous lichens or bark-loving species of mosses and hepatics. As it is, we find that over the greater part of South Lancashire the tree-trunks are destitute not only of lichens but also of the common corticole mosses, which are affected by smoke in a similar manner to the lichens. On the shady side, perhaps, the bark is coated with a film of Green Algæ, and in some cases a greenish-yellow powdery crust is present, which represents a leprarioid state of undeveloped lichens. It is significant that where lichens cannot develop on vertical

surfaces, such as tree-trunks, some species can often be found on horizontal surfaces, such as the upper edges of palings, on the top ends of posts, on prostrate trunks, or on dead twigs lying on the ground in open situations. The species occurring on bark which seem best to tolerate smoke are, principally, *Lecanora varia*, Ach., *Parmelia saxatilis*, Ach., and *P. physodes*, Ach.; next in order come *Parmelia sulcata*, Tayl., *P. fuliginosa* var. *lætevirens*, Nyl., and *Pertusaria amara*, Nyl., but usually poorly developed.

Owing to the scanty records left by earlier workers, it is impossible to estimate the number of corticole lichens which have become extinct in our district during the last century; but it may well be concluded that many of the species which are ubiquitous throughout the British Isles in all districts unaffected by smoke, must formerly have been present in South Lancashire. It is improbable that the larger foliaceous lichens, such as members of the Stictaceæ, were ever well represented here, especially in the lowland districts, as they require a wetter climate than ours. We have one old record for *Lobaria pulmonaria*, Hoffm. in the Todmorden district, and the same species formerly occurred in the Hebden Valley, in the contiguous part of West Yorkshire. This, and one or two other old records, given in our Systematic List, give a clue to the character of the former corticole Lichen-flora of South Lancashire.

Rupestral Species.—The rupestral species have been the next class of lichens to suffer from the atmospheric pollution; and the effects are particularly noticeable in the hilly districts in the eastern part of South Lancashire. The sandstone and gritstone rocks and walls of our upland districts must, formerly, have sustained a far richer and more luxuriant lichen-flora than is now the case. A comparison between the lichens of the South Lancashire hills and those of the hills further north in West Lancashire, shows so great a difference as to preclude any possibility of mere geographical situation being responsible. Not only the number of species, but also the number of individuals, is enormously reduced, and the specimens are usually more poorly developed. The reason is, of course, the smoke from the manufacturing towns which cluster thickly in "East Lancashire." Usually, these towns are situated in the valley-bottoms, and the smoke rises up and is carried on to the surrounding hills and moorlands.

The effect of this air-pollution, continued through two or three generations, has been to cause the disappearance of rupestral lichens from these districts to such an extent that only a few of the common species now survive, more particularly in sheltered cloughs and on horizontal rocks by the side of streams. Rupestral mosses are similarly affected by the unfavourable conditions, *e. g.* several common species of *Grimmia* and *Rhacomitrium*, which were formerly common in the hillier parts of South Lancashire, are now almost extinct. Moreover, it is not only the lichens of rupestral habit which are affected, for in some localities the degree of atmospheric impurity is such

as even strongly to affect lichens which grow on the ground; and the *Cladoniæ*, such as *C. coccifera* and *C. cervicornis*, on some of our moorlands are in such a depauperate condition as hardly to be nameable. In our upland districts some species of *Stereocaulon* and *Sphærophorus* should be present; and if we may judge by the general statements in the 'Flora of Todmorden' (**21** *b*), they formerly did occur, but there is now no trace of their existence.

In the coastal plain the number of possible habitats for rupestral lichens is greatly curtailed by the rarity of rock outcrops and even stone walls; but it is evident that the condition of saxicole lichens in the greater part of the low country is not much better than it is in the hills of "East Lancashire." In short, throughout the whole of South Lancashire saxicole lichens, at any rate so far as a siliceous substratum is concerned, are, to say the least, very seriously affected. We find, exactly as is the case with corticole lichens, that horizontal surfaces, such as the copings of walls, low kerbstones by roadsides, the surface of stones partly buried in the ground, and the surface of the ground itself, all yield more and better developed specimens than the perpendicular or inclined faces of rocks and walls. For example, the finest specimens of *Parmelia physodes* are to be found on bare sand-dunes, some of the thalli being several inches in diameter, whilst elsewhere our examples are small and stunted.

It has been pointed out by Wheldon & Wilson (**26**) that a calcareous substratum seems to counteract the effects of smoke on saxicole lichens. This is fully borne out by our experience in South Lancashire. We find that lichens are far commoner and better developed on limestone and mortar than on siliceous rocks. We attribute this to the circumstance that on a calcareous substratum the sulphuric acid combines with the lime to form sulphate of lime ($CaSO_4$). In this way the acid in the surface-washings is largely neutralized, and the chance of the plants receiving it in a concentration of poisonous potency is reduced to a minimum. The effectiveness of this action is to be well seen in the outskirts of a great urban district, such as on the north side of Liverpool. There we have found the following species in good fruiting condition on the mortar of walls, or on cement or concrete:—*Lecanora urbana*, Nyl., *L. campestris*, Nyl., *L. umbrina*, Nyl., *L. crenulata*, Nyl., *Verrucaria muralis*, Ach., *V. rupestris*, Schrad., var. *subalbicans*, Mudd, *Thelidium microcarpum*, A. L. Sm., and *Staurothele hymenogonia*, A. Zahlbr. Some of these frequently occur on the mortar of sandstone walls quite close to the town, whilst on the surface of the sandstone itself no other lichens are present. The small tract of Carboniferous Limestone in the South Lancashire portion of the Ribble Valley is situated in a district which enjoys the most favourable conditions of atmospheric purity to be found in the vice-county, and for that reason is less available for showing the neutralizing effects of a calcareous substratum on smoke

deposits than it would be if situated in a smokier district. Nevertheless, it is certain that the lichen-flora of the limestone more closely approaches the normal than does that of the siliceous rocks in the same district. The lichens of the Carboniferous Limestone will be dealt with more fully in the next part of our paper. It may be added that 32 per cent. of our total species are *restricted* to calcareous substrata.

B. *Condition of the Lichen-Flora in the various Districts.*

Whilst there is no part of South Lancashire in which the effects of atmospheric pollution are not felt, yet some of our districts are much less affected than the others ; and corresponding differences can be readily detected in the condition of the lichens.

"East Lancashire."—Our smokiest district is that situated in the south-eastern part of the vice-county, with Manchester at its centre, and comprising Oldham, Ashton-under-Lyne, Stockport, Stalybridge, Rochdale, Bury, and other smaller towns. A considerable portion of this area is purely urban in character, and is now destitute of lichens, whilst much of the remainder, owing to the close proximity of the towns to each other, may be called inter-urban. As a matter of fact, the whole district lying between Blackburn, Accrington, and Burnley on the north, and Wigan, Bolton, and Manchester on the south, is far too much affected by smoke to permit of anything approaching normal lichen-growth. The distribution of towns in "East Lancashire" is such that no part of the area is more than five miles from a large town. Furthermore, from whichever direction the wind blows, it brings smoke ; during westerly winds the area receives smoke from all that part of South Lancashire lying to the west, whilst, with easterly winds, smoke is brought from the large manufacturing towns of the West Riding of Yorkshire. As a consequence, in this district the lichen-flora is practically *in extremis* ; corticole species are absent, and, as will be gathered from our remarks under Section A, rupestral, and even terricole, species are very badly affected.

On the western side of this smoky area, in the hills about Chorley, Rivington, Parbold, and Billinge, a slight improvement in the condition of the lichens is manifest, but a more marked improvement will be found when we travel northwards, and reach the Forest of Pendle and the Ribble Valley.

"Ribble Valley."—Our best district for lichens is a narrow strip of country in that part of the Ribble Valley lying along the northern part of Pendle Hill, for there the influence of smoke is least felt, and calcareous rocks occur. It is owing, in a large measure, to the numerous species found exclusively in this small tract that the lichen-flora of South Lancashire is redeemed from utter poverty.

Corticole Lichens.—It is the only part of South Lancashire where corticole lichens can be said really to exist, and most of the few bark-loving species we record as actually growing on trees have been found there. On the trunks of some of the old trees near the banks of the Ribble, where doubtless they are somewhat sheltered from the effects of smoke-laden winds, a few of the commoner corticole species still survive. The following have been noted by us in the district :—*Parmelia saxatilis*, Ach., *P. physodes*, Ach., *Lecanora varia*, Ach., *Parmelia sulcata*, Tayl., *P. fuliginosa* var. *lætevirens*, Nyl., *Pertusaria amara*, Nyl., *Platysma glaucum*, Nyl., *Evernia Prunastri*, Ach. (once only and poorly developed), *Physcia tenella*, Nyl., *Lecanora subfusca*, Nyl., *L. rugosa*, Nyl., *L. chlarona*, Nyl., *Callopisma laciniosum*, A. L. Sm., *Pertusaria communis*, DC., *P. leioplaca*, Schaer., *Lecidea parasema*, Ach., *Buellia myriocarpa*, Mudd, *B. canescens*, De Not., *B. sphæroides*, Koerb., *Biatorina graniformis*, A. L. Sm., and *Acrocordia gemmata*, Koerb. Only the first six can be said to be fairly common on trees in that district. It is clear that the conditions, although relatively good, are far from being favourable enough to permit the corticole lichen-flora to assume its normal development.

Calcareous Rocks.—It is to the lichens of the calcareous rocks (mainly Carboniferous Limestone) that we turn with more interest. Unfortunately, the Carboniferous Limestone is only developed on an insignificant scale in South Lancashire as compared with its grand development in the adjoining Craven district of Yorkshire. In our area it forms a number of grassy knolls or low hills—some of which have now almost been removed by quarrying—extending N.E. from Clitheroe to the county boundary. The most prominent of them is Worsaw Hill, a conspicuous isolated eminence, situated between the village of Chatburn and Pendle Hill, and attaining an elevation of 600 ft. above sea-level. Natural exposures of the limestone rock are small and not numerous. Here and there at exposed places there are small outcrops ; but there are no true "scars," nor is there any development of limestone "pavement." Furthermore, the limestone is in places masked by glacial clay, and its peculiar edaphic influence thus nullified. It follows that the flora of the Carboniferous Limestone as represented in our area, although characteristic so far as it goes, is considerably inferior in richness and variety to that of other parts of Lancashire and Yorkshire, where the Carboniferous Limestone is developed on a grander scale and presents greater diversity in its physical features.

We have already referred to the advantages of the smoke-neutralizing action conferred by a calcareous substratum in a smoky district like ours. Apart from this, a factor of importance from a floristic point of view is that the Carboniferous Limestone has a characteristic lichen-flora of its own, and consequently this limestone tract, small though it is, has enabled us to include in our list numerous species of lichens which do not occur elsewhere in

South Lancashire.* Ecologically, too, the lichen-flora of the limestone is of interest by reason of its different facies from that of our siliceous rocks and soils. So far as our district is concerned, comparatively few species seem common to both types of substratum. With the calcareous rocks is associated the presence of numerous species, belonging more especially to the Collemaceæ and Verrucariaceæ, which are absent from our siliceous rocks. We have endeavoured, therefore, in our Systematic List to point out those species which show a decided preference for either of these two types of rock or soil. We have also attempted to record, so far as observed, some of the subtler degrees of selectivity evinced by many species of lichens in regard to the nature of their habitat. This selectivity may be illustrated by the lichens of our Carboniferous Limestone. For example, certain strongly xerophytic species seem absolutely restricted to surfaces of bare rock where there is a minimum of moisture and of organic matter, and where they are exposed to a maximum of light and air. Thus on outcrops of bare limestone rock, as on the summit of Worsaw Hill, the following species occur:—*Collema furvum*, Ach., *Pannularia nigra*, Nyl., *Squamaria saxicola*, Poll., *Placodium murorum*, DC., *P. tegularis*, Ehrb., *Lecanora irrubata*, Nyl., *L. galactina*, Ach., *L. campestris*, Nyl., *Aspicilia gibbosa*, Koerb., *A. calcarea*, Somm., *Acarospora pruinosa*, Jatta, *Lecidea immersa*, Ach., *Verrucaria nigrescens*, Pers., *V. mauroides*, Schaer., *V. maculiformis*, Krempelh., *V. rupestris*, Schrad., *V. calciseda*, DC., and *Acrocordia epipolæa*, A. L. Sm. The black patches of *Pannularia nigra*, Nyl., and *Verrucaria nigrescens*, Pers., and the orange-coloured crusts of *Placodium murorum*, DC., are conspicuous to the eye on the white rock; but it is only under a lens that the numerous less obtrusive species are visible, and the whole surface of the rock is seen to be spotted with the black fruits of the *Verrucariæ*, which often pit the rock. An analogous habitat is afforded by the limestone walls, and many of the foregoing lichens, as well as others, are common on the stones, the following being noticeable:—*Xanthoria parietina*, Th. Fr., *Placodium murorum*, DC., *P. tegularis*, Ehrb., *Physcia tenella*, Nyl., *P. stellaris* var. *leptalea*, Nyl., *Xanthoria lychnea*, Th. Fr. (rare), *Lecanora irrubata*, Nyl., *L. galactina*, Ach., *Callopisma erythrellum*, Nyl., *Aspicilia calcarea*, Somm., *Acarospora pruinosa*, Jatta, *Buellia canescens*, De Not., *Verrucaria nigrescens*, Pers., &c.

On the other hand, certain species, e. g. *Leproloma lanuginosa*, Nyl., *Urceolaria scruposa*, Ach., *Gyalecta cupularis*, Schaer., *Biatorina lenticularis*, Koerb., *Opegrapha saxicola*, Ach., *Verrucaria papillosa*, Ach., and *V. Dufourii*,

* Several species which are frequent on the Carboniferous Limestone elsewhere in the North-West of England have not yet been found with us, e. g. *Leptogium lacerum*, Gray, *L. pulvinatum*, Nyl., *Solorina saccata*, Ach., *Squamaria crassa*, Huds., *Placodium elegans*, DC., *P. candicans*, Nyl., *Leproplaca xantholyta*, Nyl., and *Dermatocarpon miniatum*, Th. Fr.

DC., are partial to bare limestone, but require some degree of dampness and shade.

Some of these calciphile species occur also on mortar of walls, and in this way obtain a wider distribution. The following have been met with only on mortar or the like, namely, *Lecanora urbana*, Nyl., *L. umbrina*, Nyl., *Lecidea atrofusca*, Mudd, *Verrucaria muralis*, Ach., *V. integra*, Carroll, *Thelidium microcarpum*, A. L. Sm., *T. incavatum*, Mudd, and *Staurothele hymenogonia*, A. Zahlbr.

In contradistinction to the foregoing species, which are true lithophytes, we may distinguish another group of lichens which require an earthy substratum with some amount of humus. The following have been met with in our area growing on the ground about limestone rocks, or in their crevices among earthy detritus and incrusting decaying mosses and other plants :—*Collema granuliferum*, Nyl., *C. pulposum*, Ach., *C. melænum*, Ach., *Collemodium turgidum*, Nyl., *Peltigera rufescens*, Hoffm., *Lecidea lurida*, Ach., *Biatorina cæruleo-nigricans*, A. L. Sm., *Bilimbia lignaria*, Massal., *Bacidia muscorum*, Mudd, and *Dermatocarpon lachneum*, A. L. Sm. (*Endocarpon rufescens*, Ach.). On horizontal limestone rock-surfaces small depressions are frequently formed by solution, and in these a black earth collects. This is a favourite habitat for *Lecidea lurida*, Ach., *Biatorina cæruleo-nigricans*, A. L. Sm., and *Dermatocarpon lachneum*, A. L. Sm. The crevices and joints of limestone walls, particularly in somewhat damp, shady situations, and where not too overgrown by moss, yield the following :—*Collema furvum*, Ach., *C. pulposum*, Ach., *C. cheileum*, Ach., *Lecanora dispersa*, Nyl., *Cladonia cæspititia*, Floerke, *Gyalecta cupularis*, Schaer., *Bilimbia aromatica*, Jatta, *B. sabuletorum*, Branth & Rostr., *B. lignaria*, Massal., and *Bacidia muscorum*, Mudd.

Another group of calcareous rocks in the same district is afforded by the strata known as the Pendleside Series, exposed on the northern slopes of Pendle Hill, and comprising a series of impure limestones and mudstones. Many of the lichens referred to in connection with the Carboniferous Limestone occur also on these rocks. They also yield *Rhizocarpon confervoides*, DC., *Lecidea ochracea*, Wedd., *Biatorina chalybeia*, Mudd, and *Bilimbia subviridescens*, A. L. Sm., which have not yet been found with us on the Carboniferous Limestone.

On the banks of the R. Ribble at Chatburn are high banks of glacial clay containing pebbles of limestone and sandstone. This locality has yielded a number of interesting lichens, more especially *Lecidea expansa*, Nyl., *Verrucaria submersa*, Schaer., *Thelidium mesotropum*, A. L. Sm., and *Microglæna nuda*, nov. spec., which occur on the exposed surface of small stones partially embedded in the clay. Many of the limestone pebbles, when extracted from the clayey matrix, are found to be pitted on all their faces by the action of former generations of lichens which lived on them and were destroyed when

the stone was turned over or buried by slipping of the ground. No doubt, whenever a fresh surface is exposed it is quickly occupied by these small *Lecideæ* and *Verrucariæ,* which seem rapidly to develop.

Littoral District.—On the coast, and in the low-lying country adjacent thereto, with the exception, of course, of those parts close to the large towns, lichens are more frequent and flourish better than in the smokier districts inland in East Lancashire. This is doubtless due to the fact that westerly winds are more prevalent than easterly winds, westward being the direction in which the air is purer than in any other, and the direction from which the strong winds blow. Nevertheless, the smoke from the large towns of Liverpool, Southport, Warrington, Wigan, Widnes, and St. Helens is sufficient to impair the atmospheric purity over the whole district to a very considerable extent, gauged by its influence on certain classes of lichens.

On an analysis of our list we find that 22 per cent. of the species occur within two miles of the sea, but they are mostly either terricole species or occur on mortared walls. Rupestral species are relatively few in number, and corticole lichens mainly occur only under special conditions.

The coast-line of South Lancashire is about 48 miles long. Only about 19 miles of the coast are, however, really maritime ; the remainder, situated in the estuaries of the Mersey and Ribble, is purely estuarine in character. The low flat coast, with its limited amount of rock, is not favourable for lichens. In the estuarine portions it consists mainly either of salt-marsh and mud-flats, which are naturally destitute of lichens, or of steep banks of glacial clay, which weather too rapidly to permit much in the way of lichen-growth. The maritime portion of the coast consists of a sandy shore backed by an extensive tract of sand-dunes, the lichen-flora of which is of particular interest and will be described presently.

Coastal Rocks.—The only rocks on the coast are two outcrops of Bunter Sandstone, namely, at Dingle Point and Hale Point, both in the Mersey estuary. These rocks have a very poor lichen florula, for the polluted air, the muddy water which washes them, and the friable nature of the rock itself, are all inimical to lichen-growth. On the rocks at Dingle Point, which is situated at the south end of Liverpool, close to the docks, the only lichens we have seen are a little *Lecanora campestris*, Nyl., on hard " fault rock," and *Cladonia fimbriata* on mossy rocks. All the bare rock below high-water mark is mud-coated, whilst the rocks above tide-level, apart from any question of smoke influence, are too friable for lichens. An adjacent sea-wall, built of harder sandstone, yields a few lichens on the sandstone blocks and on the cement, namely, *Lecanora campestris*, Nyl., *L. atrynea*, Nyl., *L. umbrina*, Nyl., *L. atra*, Ach., and *Callopisma vitellinum*, Sydow. On the low rock outcrop known as Hale Point, a few lichens still linger, although the place is only three miles from the great chemical manufacturing town of Widnes. These

are as follows :—*Lecanora atrynea*, Nyl., *L. campestris*, Nyl., *Acarospora smaragdula*, Koerb., *Callopisma erythrellum*, Nyl. (very sparingly), *C. ferrugineum* var. *festivum*, Nyl. (very sparingly), *Lecanora atra*, Ach. (in a depauperate condition), and *Verrucaria maura*, Wahlenb. (sparingly), the foregoing all fruiting. In addition, there are *Lecanora parella*, Ach. (sterile and very badly developed) and what are probably depauperate states of *Xanthoria parietina*, Th. Fr., and *Callopisma vitellinum*, Sydow. *Verrucaria maura* is the only one of the foregoing which can be called a true maritime species.

Sand-Dunes.—The range of sand-dunes which fringes the coast between the estuaries of the Mersey and Ribble is the most extensive tract of dunes in the British Isles, and is noted for its interesting plants.

The variety and attractiveness of the vegetation have led us to devote much attention to these dunes. Furthermore, on account of the situation and the nature of the habitat, the lichens on the dunes appear to be comparatively little affected by town-smoke. At first sight, the lichen-flora of these sand-hills might appear to be a very limited one; in reality, however, it is much richer and more varied than would be suspected, and, on investigation, it has yielded numerous rare, and even some new, species. The number of species of lichens occurring on the dunes to our knowledge is 39. Several other species which have been collected in dune localities, on substrata, such as old leather and decaying logs, are not included in this estimate, as they are probably more correctly regarded as, in a sense, adventive.

Lichens only form a very subordinate element of dune vegetation; but they do play a part, even if a minor one, in the fixing of the sand by vegetation. From an ecological aspect their mode of occurrence and distribution on the dunes are of interest. As a rule, lichens are amongst the earliest colonisers of bare surfaces, where the substratum is firm, such as rock, soil, or bark, and, as is well known, they help to prepare the way for the growth of mosses and flowering plants. In a dunal environment, however, such lichens as occur are largely dependent on higher plants for the creation of certain edaphic conditions requisite for their development and existence. The primary condition is that some degree of surface-fixation, produced by the growth of vegetation, must have taken place; and, secondly, for most species of dune-lichens some amount of humus seems necessary. In the sand-hills of the South Lancashire coast there are two environmental extremes which inhibit lichen-growth. These are represented, on the one hand, by growing or mobile dunes, the surface of which has not yet become fixed by vegetation and is mobile under wind action; and, on the other hand, by certain types of dune-marsh, locally called "slacks," which exist in parts of the sand-hills where the water-table is close to the surface. In the former case, it is mainly want of fixity of surface which impedes lichen development; in the latter case, there are no lichens which can develop on ground where standing-water, even if shallow, is usually present and deposition of sediment is taking

place, or where, as is often the case, there is normally sufficient moisture to produce a vigorous growth of mosses and other aquatic vegetation. The lichens of the dunes, therefore, exist in habitats of a character intermediate in varying degrees between the two extremes mentioned; and since, for the most part, lichens are of pronounced xerophilous tendencies, by far the greater proportion occurs on the sides of the dunes rather than in the "pans" or "slacks" where moister conditions prevail.

On the outer Marram-clad growing dunes, or on older dunes which have been partially denuded and are being remoulded by the wind, lichens are not present at all. On those dunes, however, where the surface is slightly fixed by the growth of Marram grass (*Ammophila arenaria*, Link), and a few other species of phanerogams and some bryophytes, lichens soon put in an appearance. It is on this type of dune, where the ground is bare and open and the degree of surface fixation but slight, that *Collemodium turgidum*, Nyl., *Leptogium scotinum*, Fr., and *Collema ceranoides*, Nyl., occur. These species spring into prominence during the cool, damp weather of autumn and winter, when the sand is moist, and the moisture helps to keep the surface firm. In places where the sand-grains have become somewhat cemented together by the growth and decay of *Nostoc* and small mosses, such as *Ceratodon purpureus*, *Barbula* spp., and *Bryum* spp., several inconspicuous rare species of *Lecideæ* have been found incrusting the decaying bryophytes, e. g. *Bacidia arceutina* var. *brevispora*, *Lecidea pleiospora*, A. L. Sm., and (rarely) *Biatorella campestris*, Th. Fr.

With the accumulation of humus due to the decay of Marram grass and other vegetation, some of the *Cladoniæ* soon appear, particularly *C. pyxidata*, Fr., *C. chlorophæa*, Floerke, and *C. fimbriata*, Fr., and these rapidly spread and form a crust over decaying moss and other humus. These *Cladoniæ* play no small part in fixing the surface and forming a soil-layer. On these open dry dunes several species of *Peltigera* also appear at an early stage. These comprise *Peltigera horizontalis*, Hoffm. *forma*, *P. canina*, Hoffm., *P. rufescens* (very sparingly), *P. spuria*, Leight. (occasionally), and *P. polydactyla*, Hoffm.; and the first two often form fairly large circular patches, with the thallus appressed to the ground. Another lichen which is prominent in the same association is *Parmelia physodes*, Ach., which starts on small partially-buried dead twigs of *Salix repens*, and often spreads in grey patches, some inches in diameter, on to the surrounding soil. Of common occurrence, also, is *Lecidea uliginosa*, Ach., the thallus of which forms a brownish film on dead Marram-grass leaves, and other vegetable débris, particularly in the shade of tufts of grass, or on the shady side of dunes. In the winter months *Bilimbia sphæroides*, Koerb., recognizable by its pale yellowish or dirty-white apothecia, is frequently met with on the barer places on this type of dune.

As vegetation increases, and a closed plant-association is formed, lichens tend to disappear; but on parts of the inland dry dunes where the conditions

favour the maintenance of an open plant-association, and the soil has become stale and leached of calcareous matter, *Cladoniæ* are abundant, but as a rule they are poorly developed, doubtless owing to the scantiness of humus. These include *C. alcicornis*, Floerke, *C. pyxidata*, Fr., *C. chlorophæa*, Floerke, *C. fimbriata*, Fr., *C. furcata* var. *spinosa*, Hook., *C. squamosa*, Hoffm., *C. pungens*, Floerke, *C. cæspititia*, Floerke, and *C. fibula*, Nyl., var. *radiata*, also *Cetraria aculeata*, Fr., &c.

In parts of the sandhill tract where "slacks" or dune-pans exist, the lower slopes of the larger dunes, and especially the low secondary dunes which rise out of the "slacks," are worth careful examination for lichens in places where the surface is clear of larger vegetation. The following have been found in such situations on damp decaying mosses, hepatics, &c. :—*Bilimbia squamulosa*, A. L. Sm., *B. sphæroides*, Koerb., *Bacidia muscorum*, Mudd, var. *atriseda* nov., *Collema pulposum*, Ach. (very rare), *Lecidea uliginosa*, Ach., and *Cladonia sylvatica*, Nyl.

Usually the dune valleys in the wetter parts of the dunes are not adapted for lichens, owing to the moist conditions which favour the development of marsh-plants and a luxuriant growth of aquatic mosses ; but in some of the more recently formed dune valleys, where stretches of moist bare ground occur, is the habitat of *Arthopyrenia areniseda*, A. L. Sm., which was first discovered in this tract of dunes, and will be referred to more fully in the Systematic List.

On portions of the sand-dunes on the South Lancashire coast are large plantations of pines, as well as some deciduous trees such as birch, alder, poplars, &c. ; but owing to the conditions of atmospheric impurity already described, corticole lichens are well nigh absent, and *Lecanora varia*, Ach., is the only lichen common on the bark of these trees. It is interesting to find, however, that a number of corticole lichens do exist on the sandhills under certain conditions. In the dune-hollows *Salix repens*, Linn., is everywhere abundant, and on the dead underground stems of this willow, exposed by wind erosion on the sides of the dunes, the following lichens have been found :—*Lecanora varia*, Ach., *Parmelia sulcata*, Tayl., *P. physodes*, Ach., *Bacidia salicicola*, nov. spec., *Lecanora symmictera*, Nyl., *L. sarcopsis*, Ach., *Buellia myriocarpa*, Mudd, *Bacidia Beckhausii*, Koerb., *Lecanora chlarona*, Nyl., and *Parmelia fuliginosa*, Nyl., var. *lætevirens*, Nyl. Only the four species first mentioned are common; the rest are rare. *Lecanora albella*, Ach., *Lecidea enteroleuca*, Ach., *L. fuliginea*, Ach., and one or two other species, have also occurred very sparingly on old bark and dead wood.

The foregoing description mentions most of the lichens which are to be found on the South Lancashire dunes, and gives some indication of their type of habitat. A few additional species, rare and local in their occurrence, are given in our Systematic List (Part V.).

IV. Resumé of Earlier Published Work.

It is a pity, in view of the great changes which have taken place in the lichen-flora of South Lancashire, that the records left by earlier workers are so scanty. Such as are available we have included in our list, and, though few in number, they are often very interesting on account of the light which they throw on the character of the lichen-flora before its deterioration had taken place.

Ray (**16** *a*), in his 'Catalogus Plantarum Angliæ et Insularum Adjacentium' (1677), gives us a single record—our oldest,—namely, *Usnea articulata*, Hoffm., "Knotted or kneed tree-moss," collected on hazel by Thomas Willisell, in the neighbourhood of Burnley. The specimen is in the British Museum Herbarium. This old record is of particular interest, as the whole genus is now extinct in South Lancashire. We find no addition to the lichen-flora of the vice-county until the time of Dillenius. In the 'Historia Muscorum' (1741) (**5**), we have our first record of *Platysma glaucum*, Nyl. and its f. *ampullaceum*, which were discovered by Richardson on Emmott Moor, near Colne.

From the time of Dillenius until the middle of the nineteenth century, we find no published reference to South Lancashire lichens except one in regard to the finding by Sir J. E. Smith (**19**) of *Lecidea lucida*, Ach., on sandstone rocks about Liverpool.

In 1859–60 Mr. F. P. Marrat (**14**), a well-known Liverpool botanist, published a paper entitled "Hepaticæ and Lichens of Liverpool and its Vicinity." This appeared as an appendix to vol. xiv. Proc. Liverpool Lit. and Phil. Soc. Marrat's paper is concerned more particularly with the Wirral district (Cheshire), which is adjacent to Liverpool. Very few localities in South Lancashire are mentioned, and some of the items are also of doubtful authenticity.

In 'The Manchester Flora,' published in 1859 by L. H. Grindon (**7**), 73 species of lichens are enumerated as occurring within the eighteen miles radius covered by the 'Flora.' In not a single instance, however, does the author give a locality for any of the species; and as the area covered by 'The Manchester Flora' includes portions of four counties, his list has not been at all useful to us. It may be added that Mr. Grindon comments on the diminution of lichens in the Manchester district "of late years through the cutting down of old woods and the influx of factory smoke."

We now come to the late Abraham Stansfield (**21**), of Todmorden, who, half a century or more ago, investigated the lichens on the Pennine Hills in the neighbourhood of his birthplace. The results of Stansfield's investigations will be found embodied in several local floras, namely the 'Flora of West Yorkshire' (**9**), the 'Flora of Halifax' (**4**), and in the more recently published 'Flora of Todmorden' (**21** *b*), which first appeared serially in the

'Lancashire Naturalist,' vols. i. and ii., 1907–1908. The list of lichens appears in vol. ii. pp. 357–360. As the Todmorden district lies partly in Yorkshire and partly in Lancashire, we are only able to include in our list those species for which definite Lancashire localities are given. Unfortunately, Stansfield's list mentions only a few Lancashire stations, but it is interesting, nevertheless, to us as showing the general character of the lichen-flora in the Todmorden district half a century or more ago, and for the evidence it affords that the deterioration of the lichen-flora had then commenced. Stansfield also contributed an interesting chapter, entitled "Observations on the Botany of the Forest of Rossendale," to Newbigging's 'History of the Forest of Rossendale' (1868). Eight species of lichens are there mentioned. In his introductory remarks Stansfield calls attention to the destruction of the flora by the influence of smoke, and to this cause he attributes the extinction of from 30 to 40 species of cryptogams "which have disappeared from the flora of the Forest during the last twenty years."

The next contribution to our knowledge of South Lancashire lichens is contained in the 'Victoria History of Lancashire' (1906). The article "Botany," by H. Fisher (**6**), gives records (supplied by one of the present authors) of 29 species of lichens found in South Lancashire.

During the past seven years the investigation of the lichen-flora has been continued by the authors, with assistance of a few friends, and the results are embodied in the present paper. A few notes and records, published during the course of the investigation, will be found in the Proc. Liverpool Botanical Society, the pages of the 'Lancashire Naturalist,' and in the 'Reports of the Lichen Exchange Club.'

V. Systematic List.

In nomenclature and arrangement the list mainly follows Horwood's 'Hand-List of the Lichens of Great Britain, Ireland, and the Channel Isles' (**8**), which is based on the 'Monograph of British Lichens,' Parts 1 and 2.

! indicates that a specimen has been seen by the authors.

Names of localities where the plant in question does not now occur are enclosed in parenthesis; and [ ] are used when a species is apparently now extinct in the vice-county.

The authors are responsible for all records in the List for which no authority is given.

The total number of species recorded for South Lancashire, and referred to in our List, appears to be 190. Of these 4 are due either to errors of identification or of locality, or the names are ambiguous. 12 of the recorded species are believed to be now extinct, and perhaps this number should be larger. With these deductions, the number of species in South Lancashire, of which there is fairly recent evidence, is 174, with 27 varieties.

In the List four species and two varieties new to science are described, namely, *Bacidia latebricola*, *Bacidia salicicola*, *Bacidia epiphylla*, *Microglæna nuda*, *Bacidia arceutina* var. *brevispora*, and *Bacidia muscorum* var. *atriseda*.

The two following varieties, namely, *Peltigera canina*, Hoffm., var. *palmata*, Duby, and *Bæomyces rufus*, DC., var. *Prostii*, Duf., which, we believe, have not previously been recorded in the United Kingdom, have been discovered in South Lancashire during our investigations.

We desire to acknowledge the kind assistance of Miss A. Lorrain Smith, F.L.S., of the British Museum, whom we have consulted on several occasions in regard to the identification of material; and we have also to thank Herr H. Sandstede for examining some of our *Cladoniæ*. We desire also to express our thanks to the following gentlemen who have helped us by collecting and sending us specimens, or in other ways, namely: A. A. Dallman (Liverpool), G. H. Hopley (Brinscall), C. R. Ritchings (Burnley), H. Robinson (Colne), C. B. Travis (Liverpool), W. Watson, B.Sc. (Greenfield), F. Williamson (Rochdale), and A. Wilson, F.L.S. (Garstang).

LIST OF SPECIES.

COLLEMACEÆ.

COLLEMA FURVUM, Ach. Rare. All our records refer to localities in the limestone area in the Ribble Valley.

On calcareous rocks of the Pendleside Series in a gully above Hook Cliffe, N.W. side of Pendle Hill, alt. *circa* 700 ft., June 1911; on mossy, mortared walls by the River Ribble near Clitheroe; also on Brungerley Bridge, Clitheroe, June 1912, *C. B. Travis & W. G. T.*

COLLEMA PULPOSUM, Ach. On damp, mossy, calcareous earth, and in the crevices of old limestone walls. Rare.

On moist, sandy soil in the sandhills, Freshfield, Dec. 1907; limestone wall by Horrocksford Bridge, near Clitheroe, March 1913.

COLLEMA GLAUCESCENS, Hoffm. (*C. limosum*, Ach.)

On banks of glacial clay fringing the estuary of the River Mersey, between Garston and Speke.

First observed in 1907, and recorded in the 'Flora of West Lancashire,' p. 439. Seen again in fair quantity near Speke, in 1911; specimens distributed through the Lichen Exchange Club, see Rept. Lichen Ex. Club, 1911, p. 12.

COLLEMA CERANOIDES, Nyl. *ex* Cromb.

Bare, sandy ground on the dunes, Hall Road, Dec. 1893.

[COLLEMA GRANULOSA, Hoffm. Southport, *F. P. Marrat*, Hep. & Lichens of Lpool. We do not know to which species this record refers; possibly *Collemodium turgidum*, Nyl., or *Collema pulposum*, Ach., was intended.]

COLLEMA CHEILEUM, Ach. On the mortar of old, mossy walls, and in the crevices of limestone rocks. Rare.

On mossy, mortared walls by the R. Ribble, near Clitheroe, June 1912; in the same kind of habitat, limestone wall by Horrocksford Bridge, near Clitheroe, March 1913; among moss on the mortar of sandstone walls, Little Crosby, Sept. 1912; crevices of limestone rocks, Bellman Hill, Worston, March 1913.

COLLEMA GRANULIFERUM, Nyl. Very rare, and occurring only on a calcareous substratum. Sterile.

On a small limestone "scar" below Pendle Hill.

The record for Birkdale, *Vict. Hist.* p. 82, was an error, the plant referred to being a granular state of *Collemodium turgidum*.

COLLEMA MELÆNUM, Ach. Very rare, and only seen in a sterile condition.

On earth among limestone rocks, Worsaw Hill, Chatburn, May 1910.

COLLEMODIUM TURGIDUM, Nyl. *ex* Lamy. On calcareous earth in the limestone area in the Ribble Valley; also on shelly sand in the coastal dunes.

Frequently seen in autumn and winter on bare or scantily moss-covered ground in the sandhills at Formby, Freshfield, Churchtown, &c.; on earth among limestone rocks, Worsaw Hill, Chatburn, May 1910.

A form occurs on the sand-dunes in which the apothecia appear to remain permanently more or less urceolate and sunk in the thallus.

HOMODIUM TENUISSIMUM (Koerb.) Horw.

Among mosses on a sandy bank in the dunes, Formby, Oct. 1911 and Feb. 1912. Only seen in a sterile condition.

[LEPTOGIUM LACERUM, Gray.

"Cotteral Clough, Lancashire," *Mon. Brit. Lichens*, i. p. 70.]

This locality is in Cheshire; but the plant is so frequent on the limestone in West Lancashire, that further careful search will no doubt prove it to occur in the Ribble district.

LEPTOGIUM SCOTINUM, Fr.

Dry, mossy banks among the sandhills, more particularly on the outer dunes where the surface is but scantily moss-grown. Frequent. It has been collected in good fruiting condition in various parts of the sand-dune tract, as at Hightown, Formby, Freshfield, &c. It is most conspicuous in autumn and winter, and difficult to find during the summer. The var. SINUATUM (Malbr.) is, perhaps, as frequent as the type.

This species is only known, as yet, with us on the sandhills, but should be looked for on mossy banks and walls in the limestone area in the Ribble Valley.

STICTACEÆ.

[LOBARIA PULMONARIA, Hoffm. "Lungwort." On the bark of old trees, Sheddon Clough, near Burnley, *Fl. Todmorden.*] Long extinct.

Also used to occur, formerly, in the Hebden Valley, in the adjacent part of Yorkshire, *Fl. West Yorks.*

One of several old records which are of particular interest now-a-days to all who know the present deplorable state of corticole lichens in South Lancashire. It makes us realize vividly the great havoc which has been wrought in our cryptogamic flora by the enormous development of manufacturing industry in Lancashire during the past century.

PELTIGERA CANINA, Hoffm. On mossy banks in the dunes, and among herbage and mosses on the ground in upland districts. Rather rare except on the dunes; fruit, very rare.

Sandhills, Formby, Freshfield, Ainsdale, &c.; sandy ground near Mere Brow; dry bank at the base of a wall, Law Farm near Colne, and on a roadside bank near Alma Inn, Laneshaw Bridge, *H. Robinson.*

Var. PALMATA, Duby. Dry sand-dunes between Freshfield and Ainsdale, fruiting, Nov. 23, 1913.

Distinguished by the border of the thallus being divided in small palmate lobes, each terminating in a small apothecium. Apparently not previously recorded in the British Isles.

PELTIGERA RUFESCENS, Hoffm. Among thin herbage on the ground in the older parts of limestone quarries and among limestone rocks and on walls; occurs also on mossy parts of dry sand-dunes on the coast. Not seen in fruit.

Frequent in the limestone area in the Ribble Valley about Chatburn and Clitheroe; sandhills at Formby and Ainsdale, but very sparingly.

PELTIGERA SPURIA, Leight. On peaty earth amongst pine-trees, and also on sand-dunes.

Simmonswood Moss, luxuriant and fruiting, Sept. 1893, and again in May 1908, *Rept. Lichen Ex. Club*, 1911; on sand-dunes near West End Farm, Ainsdale, Aug. 1914.

PELTIGERA POLYDACTYLA, Hoffm. Amongst short herbage on the ground. Occasional in inland localities, but frequent on the sandhills.

Old quarry, Aughton, *A. A. Dallman* and the authors, March 1907; Simmonswood Moss; sandhills at Ainsdale and Freshfield.

PELTIGERA HORIZONTALIS, Hoffm. On dry, bare mossy banks on the sandhills, not unfrequent.

Sandy ground behind the sea-embankment, Crossens, fruiting, March 1898; Hall Road, Dec. 1893; observed since at various points along the sand-dune tract, as at Birkdale, Freshfield, and Formby.

PANNARIACEÆ.

PANNULARIA NIGRA, Nyl.

Not unfrequent on bare limestone rocks and walls, but confined to the Carboniferous limestone in the Ribble Valley. Specific localities which may be mentioned are: Worsaw Hill and other places about Chatburn, Bellman Hill near Worston, and walls by the roadside between Chatburn and Downham, *C. B. Travis & W. G. T.*

LEPROLOMA LANUGINOSUM, Nyl.

Shady calcareous rocks. Rare. Fruit unknown. In a gully on the north side of Pendle Hill, alt. 850 ft., June 1908, *A. Wilson*; Worsaw Hill, June 1911.

RAMALINACEÆ.

RAMALINA CALICARIS, Nyl.

Very sparingly, and in a stunted and sterile condition, on a stump on the shore at Banks, May 1909.

[USNEA FLORIDA, Ach. On stones and trees, Thieveley Scouts, *Fl. Todmorden.*]

Extinct. This old record may possibly refer to *U. ceratina*, Ach., var. *scabrosa*, which still occurs on trees and rocks in the adjoining vice-county of West Lancashire.

[USNEA ARTICULATA, Hoffm.

"*Muscus arboreus nodosus sive geniculatus.* Knotted or kneed tree moss. This T. W. brought to me at Burnley in Lancashire, where he found it growing on an Hasell Nut-tree." *Ray*, Cat. Plantarum Angliæ, &c., ed. 2 (1677), p. 203. "In Lancastria, prope Burnley, pagum e *Corylo* dependentem invenit Th. Willisell," *Ray*, Synopsis, ed. 2 (1696), p. 22. On beech near Burnley, *Dillenius.*]

Long extinct. These are the oldest records of Lancashire lichens that we have; and are eloquent of the vast changes that have taken place in the flora of South Lancashire. Usneas still linger sparingly in West Lancashire, but in South Lancashire the whole genus is extinct, and has been for at least a generation.

CETRARIA ACULEATA, Fr. On bare, peaty soil on some of the higher hills, where it is not uncommon locally; also, sparingly, on the sandhills. Sterile.

Forest of Rossendale, *Stansfield*; on the summit ridge of Boulsworth Hill, *H. Robinson*!; summit of Pendle Hill, 1830 ft.; Ainsdale sandhills, 23 March 1898; bare spots on dry grassy dunes, Formby, May 1913.

PLATYSMA GLAUCUM, Nyl. On walls, rocks, and occasionally on tree-trunks. Not uncommon, locally, in some of our upland districts, but very rare in the low country. Sterile, and often in a stunted condition.

"*Lichenoides endiviæ foliis crispis, splendentibus, subtus nigricantibus*, Rich. Richardson, in pascuis montosis Emmot More dictis prope Coln." *Hist. Musc.* (1741) p. 192. Littleborough, herb. *Molineux*; Brinscall, *G. H. Hopley* !; Blacko Foot, Wycollar, and other places in the neighbourhood of Colne, *H. Robinson* !; on mossy boulders, Watermeetings near Colne; on an old piece of timber in the sandhills, Freshfield, April 17, 1909. Common on trees, Ings Beck near Chatburn, June 1914.

[f. AMPULLACEUM, Cromb. *Lichenoides saxatile tinctorium foliis latioribus non pilosis, vesiculas proferens*, Dill. in *Ray Syn.* ed. 3, p. 74, n. 71. "*Lichenoides tinctorium glabrum, vesiculosum*, The Bladder Cork, ... Rich. Richardson in pascuis montanis, Emmot Pasture, dictis prope Coln . . . ." Dillenius, *Hist. Musc.* p. 188. "*Lichen ampullaceus.* On Emot Pasture, near Coln, Lancashire, Richardson, who sent a specimen of it to Dillenius," *Withering*, ed. 3, iv. p. 61; ed. 4 (1801) p. 60. "A monstrosity caused by the presence of the parasite, *Abrothallus Smithii*, near Colne, where it was originally detected," *Mon. Brit. Lichens*, i. p. 227.] See under *Buellia Parmeliarum*, H. Olivier.

PARMELIACEÆ.

EVERNIA PRUNASTRI, Ach. On tree-trunks. Very rare, and so poorly developed as to be barely recognisable.

Langho, *Vict. Hist. Lancs.*, p. 83.

EVERNIA FURFURACEA, Fr. On Millstone Grit rocks and walls in the hills. Rare, all our records referring to the Forest of Pendle area. Stunted and always sterile, but appears to resist smoke better than the next preceding.

Pendle Hill; on a wall at Blacko Tower, near Colne !, rocks above Wycollar !, walls near the golf-links, Colne, *H. Robinson* !

The f. SCOBICINA, Nyl., sparingly on the top of a sandstone wall, Twiston Moor, June 1914, *C. B. Travis & W. G. T.*

PARMELIA SAXATILIS, Ach. On walls and rocks of sandstone and gritstone, not uncommon; also on trees in the less smoke-affected parts of our area. Sterile.

PARMELIA SULCATA, Tayl. On tree-trunks and also on old walls. Not rare. Sterile, and rarely well developed.

Near Netherton, 1904; Maghull; on a tree by the Ribble, Chatburn, *A. A. Dallman & J. A. W.*; wall on the sandhills, Hightown, Jan. 1905;

on stones at the base of landmark, Freshfield; on an old log on the sandhills, Freshfield; masonry of a bridge over the R. Alt near Aintree, May 1910; on ash and sycamore by the R. Ribble near Clitheroe, June 1912; in good condition, on dead willow-twigs and on the adjacent ground, on the sandhills, Formby, March 1914.

PARMELIA OMPHALODES, Ach. On Millstone Grit rocks in the hilly districts. Very rare. Sterile, and only seen in a depauperate condition.

Forest of Rossendale, *Stansfield*; sparingly on flat Millstone Grit rocks and peaty earth, Noyna, near Colne, *H. Robinson & W. G. T.*, May 1913.

As compared with the abundance of this species on the Millstone Grit rocks of West Lancashire, its scarcity on our South Lancashire hills is striking evidence of the different conditions which prevail.

[PARMELIA CAPERATA, Ach. Trunks of old trees, Sheddon Clough, *Fl. Todmorden.*]

Extinct. There are specimens in herb. *Leyland* from the above-mentioned locality, vide *Fl. Halifax*, p. 221.

PARMELIA FULIGINOSA, Nyl. Siliceous rocks and walls, not uncommon in some districts; more rarely on tree-bark. Sterile.

Netherton, *Vict. Hist.* p. 83; Whalley, May 1909; between Barrowford and Barley Moor, *A. Wilson*; bridge over the R. Alt near Aintree, May 1910; wall on Pendle Hill, alt. 900 ft., June 1911; damp stones in glacial drift, Watermeetings, near Colne, May 1913; very fine on flat gravestones in the churchyard, Hale, 1912.

Var. LÆTEVIRENS, Nyl. On the bark of a hawthorn, Worsaw Hill, Chatburn, May 1910; on willow-bark, Woodvale, July 26, 1913; on twigs of *Salix repens* on the sand-dunes, Formby; on a tree by Ings Beck, near Chatburn, June 1914.

PARMELIA PHYSODES, Ach. Walls, tree-trunks, and sandy dune-banks; not uncommon locally. Sterile.

Between Barrowford and Barley Moor, *A. Wilson*; common in the Colne district, *H. Robinson*; occurs not unfrequently in fine patches on the exposed roots and dead twigs of *Salix repens*, and on the adjacent ground, on dry dunes in the sandhills at Hightown, Formby, and Freshfield.

The f. LABROSA on a prostrate tree-trunk, Mearley Clough, Pendle Hill, May 1910.

PHYSCIACEÆ.

XANTHORIA PARIETINA, Th. Fr. On walls, rocks, and (rarely) on the bark of trees. Very common, and fruiting well, on limestone in the Ribble Valley, but rare in other parts of the vice-county on siliceous rocks and masonry. The rarity in the greater part of our district of this common lichen is remarkable, and its scarcity on any but limestone rock seems good evidence of the favourable influence of a calcareous substratum on lichen-growth in our area.

f. CINERASCENS, Leight. With the type, and very distinct from it, near Downham, June 1908, *A. Wilson*; on an old wall at the golf-links, Law Farm near Colne, 1910, *H. Robinson* !

Var. ECTANEA, Nyl. On a limestone gate-post in a lane leading from Worston to Downham, March 1913.

XANTHORIA POLYCARPA, Fisch.-Benz.

Sparingly, on tree-stumps on the shore, Banks, May 1901.

XANTHORIA LYCHNEA, Th. Fr.

In a sterile condition, on a limestone wall near the R. Ribble, Low Moor, Clitheroe, June 1914, *C. B. Travis & W. G. T.*

PHYSCIA PULVERULENTA, Nyl. On tree-trunks. Very rare, and always poorly developed.

Littleborough, herb. *Molineux* **(17)** (specimen not seen by us), doubtless now extinct in that locality; Kirkby, *Vict. Hist. Lancs.* p. 84; on an ash-tree near Chatburn Station, 1907.

PHYSCIA PITYREA, Nyl. Very rare and rupestral only. Sterile.

Amongst moss on the horizontal surface of gritstone coping of a culvert near Longton, Dec. 26, 1911.

PHYSCIA STELLARIS, Nyl., var. LEPTALEA, Nyl. Contrary to its usual habit, rupestral only in South Lancashire. Sterile, and depauperate.

Kirkby, *Vict. Hist. Lancs.* p. 84; rather common on limestone walls and gate-posts about Chatburn and Downham.

PHYSCIA TENELLA, Nyl. On rocks and walls, and (once only) on bark. Rare. Sterile.

(Moseley Vale) *F. P. Marrat*, Hep. & Lichens of Lpool; "on ferrugineous rocks, Cliviger," *Fl. Todmorden*; limestone walls, Chatburn, Downham, and near Twiston; on the bark of a tree near Smithies Bridge, Chatburn, March 1913.

PHYSCIA CÆSIA, Nyl. Very rare. Sterile.

On limestone rocks near Chatburn, March 1907, *A. A. Dallman & J. A. W.*; on kerbstones of gritstone or sandstone on the roadside between Aintree and Maghull, Oct. 1910.

LECANORACEÆ.

[PSOROMA HYPNORUM, Hoffm.

Shaly banks, Thievely Scouts, *Fl. Todmorden.*]

No later record, and probably now extinct.

SQUAMARIA SAXICOLA, Poll. Very rare. Sterile.

(On the wall opposite Greenbank Road, Smithdown Lane, Liverpool), *F. P. Marrat*, Hep. & Lichens of Lpool; limestone rocks near Chatburn, 1907, *A. A. Dallman & J. A. W.*

PLACODIUM MURORUM, DC. On limestone rocks and walls. Not rare in the Ribble Valley.

Chatburn; near Downham, *A. Wilson*; Worsaw Hill, Chatburn.

PLACODIUM TEGULARIS, Ehrh. Common, and fruiting well, on limestone walls by roadsides about Chatburn and Downham.

PLACODIUM DISSIDENS, Nyl.

Several small patches on the gritstone masonry of two bridges on the Cheshire Lines Railway near Woodvale Station, Aug. 1914.

CALLOPISMA LACINIOSUM, A. L. Sm. (*Lecanora laciniosa*, Nyl.) Very rare. Sterile.

On the bark of an ash-tree by the R. Ribble, near Clitheroe, June 8, 1912.

CALLOPISMA VITELLINUM, Sydow. On siliceous rocks and walls; not uncommon, and occurring in all but the most smoke-affected districts.

Maghull; kerbstones of roadsides between Aintree and Ford, Oct. 1907; in an old sandstone quarry, Little Crosby, June 1909; on the coping of a culvert near Longton, Dec. 1911; on walls, Billinge Hill; near Rivington, alt. 500 ft., June 1912, *A. Wilson*; walls of Huntroyde Demesne, Padiham; in fine fruit on walls by the Ribble near Clitheroe, June 1912; on the sea-wall at Dingle Point, Liverpool, March 1914; on sandstone on a colliery refuse-heap near Rainford.

Var. AURELLUM, Ach. On a wall by the shore, Birkdale, June 14, 1912.

CALLOPISMA EPIXANTHUM, A. L. Sm.

On a wall by the shore, at Birkdale, June 14, 1912, fruiting; associated with the next preceding species.

CALLOPISMA CITRINUM, Koerb. (*Lecanora citrina*, Ach.) On the mortar of walls; not common, rarely fruiting.

Whalley, May 1902; Holme near Burnley; Speke; between Aintree and Ford; walls near Maghull, May 1910; Little Crosby, June 1909. Laneshawbridge, Colne, fruiting, *H. Robinson* !

This species shares with *Xanthoria parietina* and *Buellia canescens* a great partiality for villages and farms, or garden walls near habitations.

CALLOPISMA ERYTHRELLUM, Nyl.

Very sparingly, on sandstone rocks, Hale Point, July 1910; in poor condition, on shady limestone rocks by the road between Worston and Chatburn, March 1913; on the flat surface of a limestone block in a wall by Ings Beck, Chatburn, June 1914; on a limestone gate-post between Chatburn and Clitheroe, June 1914.

CALLOPISMA FERRUGINEUM, Nyl., var. FESTIVUM, Nyl. On siliceous rocks and walls. Very rare.

Smithies Bridge, near Chatburn, May 1910; sparingly on sandstone rock, Hale Point, July 1910.

CALLOPISMA PYRACEUM, Sydow.

Abundantly on mortar and on the stonework of bridges on the Cheshire Lines Railway, near Woodvale, Aug. 1914.

[HÆMATOMMA VENTOSUM, Massal. (*Lecanora ventosa*, Ach.)

Only one old record is known to us, and the present existence of this species in our area is very doubtful.

Walls at Aigburth, and near Roby, Liverpool, *F. P. Marrat*, Lpool Nat. Scrap-Book, p. 191.]

In West Lancashire, where the conditions are more favourable to its growth, it does not descend below 500 ft., and has a distinctly montane range.

LECANORA IRRUBATA, Nyl. (*L. rupestris*, Sm.)

On calcareous rocks. Frequent in the limestone area in the Ribble Valley about Clitheroe and Chatburn.

On limestone rocks by Chatburn Station, 1907, *A. A. Dallman & J. A. W.*; near Whalley, May 1909; on exposed limestone rocks, Chatburn, May 1910; on soft, black, calcareous shaly rocks by the side of the R. Ribble, Chatburn, June 1911; on the same kind of substratum in Horrocksford Quarries, Clitheroe, March 1913; on walls by the road between Chatburn and Downham, March 1913.

LECANORA CIRCINATA, Ach.

On the masonry of Brungerly Bridge, near Clitheroe, June 8, 1912.

LECANORA GALACTINA, Ach. On rocks and walls (mainly limestone); also on the mortar of walls. Rare.

Near Chatburn Station; Smithies Bridge, near Chatburn; sparingly, on a wall by the sea, Birkdale, June 1912; in fine condition, and fruiting well, on a horizontal gritstone coping of a culvert, near Longton, Dec. 1911; on a half-buried stone in a footpath near Cock Bridge, Whalley, March 1913. On walls (gritstone) near Colne, *H. Robinson* !

LECANORA DISPERSA, Nyl.

On mossy, mortared walls by the Ribble near Clitheroe, fruiting, June 8, 1912.

LECANORA URBANA, Nyl. On the mortar of old walls. Rare.

Walton, Liverpool, Dec. 1909; Fazackerley; and on a wall facing the sea at Waterloo, Sept. 1912.

LECANORA SUBFUSCA, Nyl. On trees, and on rocks and walls; the type very rare, the variety not common.

Tree-stumps on the shore, at Banks, May 1909. Near Downham, June 1914, *C. B. Travis & W. G. T.*

Var. CAMPESTRIS, Nyl. On the mortar of walls, Little Crosby, June 1910; sandstone rocks, Hale Point, July 1910; on the wall of Kirkdale cemetery, Fazackerley, 1913; on limestone rocks, Chatburn; on sandstone blocks in a sea-wall, Dingle Point, and on sandstone rock at the same place, March 1914; on cement or concrete at the base of the landmark, Freshfield, May 1914; on mortar of railway bridges near Woodvale, Aug. 1914.

LECANORA ALLOPHANA, Nyl. On tree-trunks. Very rare, and perhaps now extinct.

Kirkby, *Vict. Hist. Lancs.* p. 84.

LECANORA RUGOSA, Nyl. On the bark of trees, also on rocks. Rare.

Limestone rocks near Chatburn Station; abundantly on a prostrate tree-stump on the shore, Hale, July 1910; on a tree by the roadside, near Smithies Bridge, Chatburn, March 1913.

LECANORA CHLARONA, Cromb. On the bark of trees; also on exposed roots of *Salix repens* on the sand-dunes. Rare.

On the bark of a roadside tree, near Smithies Bridge, Chatburn, March 1913 (a form with very small apothecia, with a rapidly disappearing thalline margin, which we refer to the var. *lecideina*, Oliv.); on *Salix repens* near Ainsdale, and on an old log on the sandhills, near Freshfield, 1913.

LECANORA ATRYNEA, Nyl. On sandstone rocks and masonry. Very rare. The only two localities known to us are on the Mersey estuary.

On a sea-wall by Dingle Point, April 1910; Hale Point, July 1910, and May 1913; see *Lanc. Naturalist*, iii. (1910), p. 71.

This lichen had previously been found by one of us on sandstone rocks on the opposite bank of the River Mersey, at Eastham, the identification of the latter examples being confirmed by Miss A. L. Smith.

LECANORA ALBELLA, Ach. Very rare.

A single patch, in a depauperate condition, on dead twigs of *Salix repens*, on the sandhills at Formby, April 1913.

LECANORA UMBRINA, Nyl.

On a concrete wall in a shady quadrangle, Walton Prison, Liverpool, June 7, 1913; also on mortared walls in the same locality, Feb. 1914; plentifully on the cement of a sea-wall at Dingle Point, Liverpool, March 1914. Gritstone wall, Broach Flat Farm, near Colne, *H. Robinson* !

LECANORA CRENULATA, Nyl. On sandstone rocks and walls, also on mortar. Not uncommon in some of our districts, and fruits well.

Sandstone walls, Kirkby; masonry of a bridge near Banks, March 1909; gritstone blocks on the canal side, Aintree, Sept. 1909; abundantly on the mortared wall of Everton Cemetery, Fazackerley, April 1913; on a wall by the sea, Birkdale, June 1912; on a limestone wall, Heyroyd, Dec. 1913, *H. Robinson* ! Walls near Colne, *H. Robinson* !

LECANORA HAGENI, Ach.

On cement at the base of landmark, Freshfield, May 1914.

LECANORA SULPHUREA, Ach. On siliceous rocks and walls. Not common, and often sterile and depauperate in some parts of our district.

Old sandstone quarry, Little Crosby, June 1909, sterile; sandstone walls, Little Crosby, fruiting sparingly, June 1909 & 1910; walls of Millstone Grit, Heapey and Brinscall; gritstone rocks in Mearley Clough, Pendle Hill, alt. 800 ft., June 1911; walls of Huntroyd Demesne, Padiham, May 1912; walls by the R. Ribble near Clitheroe, June 1912; sandstone rocks, Hey Slacks Clough, Boulsworth Hill, Dec. 1913, *H. Robinson* !

LECANORA VARIA, Ach. On tree-trunks, old wooden palings, and dead sticks and twigs. Common, and often fruiting well. We have records for this species from practically all parts of our area, and it seems to be one of the few corticole lichens that can tolerate smoke. We have seen it at various altitudes, from sea-level up to about 1750 ft., *i. e.* on stems of crowberry on the summit of Boulsworth Hill.

Lecanora conizæa, Nyl. On palings on which bark remained. Perhaps adventive, and not belonging to our flora.

Maghull, *Vict. Hist. Lancs.* p. 84. Palings at Ford, Nov. 1905.

Lecanora conizæoides, Nyl.

On a wooden post, Formby, Jan. 1914.

Lecanora symmictera, Nyl.

Palings near Maghull Station; on stumps on the shore at Banks, May 1909; sparingly, on dead twigs of *Salix repens*, on the sandhills, Formby, March 1914.

Lecanora polytropa, Schaer. On siliceous rocks and stones. Rare.

Crompton Moor, 1909, *W. Watson*! According to Mr. Watson, this species is common on the gritstone in the district on the Yorkshire border near Oldham.

On a boulder on the shore near Hale Point, 24 June 1913 (var. *illusoria*); on sandstone blocks at base of landmark, Freshfield, May 1914; on gritstone masonry of a railway-bridge near Rainford, July 1914.

Lecanora intricata, Nyl. Subalpine siliceous rocks. Rare.

Sparingly, on gritstone rocks at the summit of Boulsworth Hill, 25 May 1912. Associated with *L. badia*, Ach.

[Lecanora carneolutea, Ach. "On a wall of Mr. Gladstone's, between Broad Green and Roby," *F. P. Marrat*, in Proc. Lpool Lit. & Phil. Soc. xv. (1861) p. 16.]

It is impossible to say what this refers to now—probably not to *Gyalecta carneolutea*, Boist.

Lecanora sarcopsis, Ach.

Sparingly, on dead twigs of *Salix repens* on the sandhills at Formby, March 1914. It occurred in association with *Buellia myriocarpa*, *Bacidia salicicola*, and *Parmelia sulcata*.

Lecanora atra, Ach. On sandstone rocks and walls, especially near the sea. Rather rare, but probably much commoner formerly. In some of the stations mentioned below it is only barely recognizable, and is on the point of extinction.

Maghull, Feb. 1904; on a sea-wall at Dingle Point, June 1908; river-wall at the Oglet, near Hale, April 1909; roadside walls between Aintree and Maghull, Oct. 1910; on a bridge near Twiston, June 1911; sparingly, and in a depauperate condition, on rocks, Hale Point, May 1913. Walls, Law Farm, near Colne, *H. Robinson*!

Var. grumosa, Ach. On the park walls of Crosby Hall, Little Crosby, fruiting, April 28, 1912.

LECANORA BADIA, Ach. On rocks and walls of Millstone Grit in the hills. Rare.

S.E. side of Pendle Hill, Aug. 1908, *A. Wilson* !; rocks on the summit of Boulsworth Hill, May 1912; wall near Rivington, June 1912, *A. Wilson* !

LECANORA PARELLA, Ach. On sandstone rocks and walls. Rare, and in some of the stations poorly developed and sterile.

Sheddon Clough, *Fl. Todmorden*; Netherton; Pendle Hill; copings of Smithies Bridge, near Chatburn, May 1910; very sparingly, at Hale Point, July 1910; Pendle End bridge, near Downham.

RINODINA EXIGUA, Gray.

On stones in a wall banked with earth, near the "Old Roan," Aintree, 1906.

ASPICILIA GIBBOSA, Koerb. (*Lecanora gibbosa*, Nyl.)

On exposed, bare limestone rocks, Worsaw Hill, Chatburn, May 1910.

ASPICILIA CALCAREA, Somm. On bare surfaces of limestone rocks and walls. Not uncommon in the limestone tract in the Ribble Valley.

Worsaw Hill, Chatburn, Sept. 1910; clough above Hook Cliffe, Pendle Hill, June 1911; roadside walls about Chatburn, Clitheroe, and Downham.

Var. CONTORTA, Nyl. On black, calcareous shales, Horrocksford Quarries, Clitheroe, March 1913.

ACAROSPORA SQUAMULOSA, Th. Fr.

On old bricks and stones on an old colliery refuse-heap, Reeds Moss, Rainford, July 1914.

ACAROSPORA SMARAGDULA, Koerb.

On sandstone rocks at Hale Point, R. Mersey; also on low rock outcrops and detached pieces of sandstone on the shore at the same place, Aug. 1912; on the sandstone copings of walls, Freshfield, May 1914.

ACAROSPORA PRUINOSA, Jatta.

On mortar of an old wall near Parbold, *A. A. Dallman & W. G. T.*; on limestone walls by the roadside between Chatburn and Downham, March 1913; on mortar of a wall near the golf-links, Colne, Dec. 1913, *H. Robinson* ! Plentifully on concrete slabs on the promenade, Ainsdale Beach.

Var. IMMERSA (Fr.). On bare limestone rocks, Worsaw Hill, Chatburn, March 1913.

ACAROSPORA PRIVIGNA, Nyl. On masonry of a railway-bridge at Maghull, *Vict. Hist. Lancs.* p. 84.

ACAROSPORA SIMPLEX, Jatta.

On gritstone masonry of a canal-bridge, Aintree, Nov. 1905; the f. *complicata*, Cromb., in the same place, Oct. 1910; abundant and fruiting freely, on the faces of gritstone blocks in the masonry by the R. Alt by the main road between Aintree and Maghull, Oct. 1910; very common on sandstone copings of walls about Birkdale and Southport.

PERTUSARIACEÆ.

PERTUSARIA AMARA, Nyl.

Tree-trunks. Only known with us to occur sparingly, and in a poorly developed and sterile condition, in a few localities in the Ribble Valley area in the neighbourhood of Clitheroe and Chatburn. One of the few common corticole lichens which still linger in the least smoke-affected part of South Lancashire.

PERTUSARIA COMMUNIS, DC. Tree-trunks. Very rare.

On the bark of an elm by the R. Ribble near Clitheroe, June 1912; also observed on ash in the same neighbourhood, occurring along with *Lecanora varia* and *Parmelia sulcata*, and the moss *Dicranoweisia cirrata*.

PERTUSARIA LEIOPLACA, Schaer.

On the bark of a holly-tree in a hedge near Downham, June 1914, *C. B. Travis & W. G. T.*

PERTUSARIA DEALBATA, Nyl. *ex* Cromb. On gritstone rocks. Very rare and sterile.

In a discoloured and degenerate state on stones, Green's Clough, near Todmorden, May 1912; on gritstone walls, Whalley Nab, and other places about Whalley, March 1913; on sandstone walls, Rivington Pike, June 1914.

THELOTREMACEÆ.

URCEOLARIA SCRUPOSA, Ach. Very rare.

Rainford, *Vict. Hist.* p. 84; Clitheroe, 1906; on shady, limestone rocks, Worsaw Hill, Chatburn, May 1910.

GYROPHORACEÆ.

GYROPHORA POLYPHYLLA, Turn. et Borr. Very rare. Sterile.

Occurs very sparingly, and in a depauperate state, on sloping rock-faces of Millstone Grit, Noyna, near Colne, alt. *circa* 950 ft., May 1913, *H. Robinson, C. B. Travis,* and *W. G. T.* The specimens were extremely stunted, and probably represent the last survivors in the vice-county of a species which, formerly, must have occurred on all the gritstone rocks on the summits of our higher hills.

CLADONIACEÆ.

BÆOMYCES RUFUS, DC. On damp, shady sandstone rocks and earthy banks. Rare.

Old quarry, Kirkby; Moorisles Clough, near Burnley, Jan. 1913, *C. R. Ritchings*! On rocks in a gully above Hook Cliffe, Pendle Hill.

Var. PROSTII, Duf. Hey Slacks Clough, Boulsworth Hill, May 1913, *H. Robinson & W. G. T.*

This variety does not appear to have been previously recorded from any British locality; we therefore give the following description of it:—Thallus granulose-verrucose, the verrucæ often pulverulent; apothecia large, convex, sessile, difform, or two to four connate and forming a mass reaching 3 mm. in diameter.

[BÆOMYCES ROSEUS, Pers.

On stones and on the adjacent ground in a wood at Woolton, *Rev. H. H. Higgins & F. P. Marrat*, Hep. & Lichens of Lpool.]

No later record, and the present existence of this species in our district is uncertain.

[ICMADOPHILA ÆRUGINOSUS, DC.

Forest of Rossendale, *A. Stansfield* (**21**).]

Apparently extinct.

[STEREOCAULON PASCHALE, Fr.

On walls, Rainhill, *Rev. H. H. Higgins*, Hep. & Lichens of Lpool.]

Undoubtedly an error, as the true plant only occurs sparingly on some of the highest Scottish mountains; nor can we guess with any probability what the lichen really was.

CLADONIA ALCICORNIS, Floerke. Dry, bare, mossy ground in the sandhills. Not uncommon. Sterile.

Formby, April 1907; in the same locality, Sept. 1908, *Rept. L. E. C.* 1911; Ainsdale, June 1907. Seen subsequently on several occasions in various parts of the sand-dunes, particularly near Ainsdale.

CLADONIA PYXIDATA, Fr. On dry banks, walls, peaty moorlands, sand-dunes, &c. Common, and recorded from all parts of our district. Fruiting occasionally.

Var. POCILLUM, Fr. Rainford Moss, 1898; sandhills between Hall Road and Hightown, Dec. 1893; Formby, Jan. 1914; Freshfield; Ainsdale; Worsaw Hill, Chatburn.

Var. CHLOROPHÆA, Floerke. On the sandhills, Birkdale, Nov. 1906; Freshfield, May 1914, *teste* Herr Sandstede.

f. LEPIDOPHORA, Floerke. Sandhills, Formby, 1907.

f. MYRIOCARPA, Cromb. Sand-dunes near West End Farm, Ainsdale.

CLADONIA FIMBRIATA, Fr. On banks and on the ground. Not uncommon, and abundant on some parts of the sand-dunes. Sterile.

Var. CONISTA, Nyl. Dunes at Freshfield and near West End Farm, Ainsdale, Aug. 1914.

The f. EXIGUA, Cromb., on sandstone rocks, Knots Hole, Dingle Point. Frequent on dead and decaying stools of Marram grass on dunes from Formby to Birkdale.

Var. TUBÆFORMIS, Fr. Netherton; Fazackerley, 1898, and rail-banks near Kirkby, Feb. 1904.

CLADONIA FIBULA, Nyl., var. RADIATA, Nyl. *ex* Cromb.
Sand-dunes, Hightown, 1906.

CLADONIA CERVICORNIS, Schaer. On peaty ground in the hills. Rare, and often in a depauperate condition in the smokier districts. Sterile.

Blacko-Foot, near Roughlee, 1909, *H. Robinson* ! ; on bare peat on the moor, Blackstone Edge, May 1912 ; Noyna, near Colne.

CLADONIA FURCATA, Hoffm. On peaty soil, and also dry, mossy, sandy ground. Frequent in the hilly districts, and also on the sand-dunes. Fruit not seen.

Var. SPINOSA, Hook. Sandhills, Hall Road, Hightown, Formby, and other places.

CLADONIA PUNGENS, Floerke. Not uncommon on dry mossy ground on the sandhills. Sterile.

Golf Links, Hall Road, 1893 ; Hightown, 1897 ; Ainsdale, 1898 and 1914 ; Formby, 1907 ; Freshfield, April 1914 ; f. *foliosa*, Floerke, on dunes near West End Farm, near Ainsdale.

CLADONIA SQUAMOSA, Hoffm. Rare, or perhaps overlooked. Sterile.

At the base of a wall, Downham road, Blacko, Sept. 1909, *H. Robinson* ! The f. *turfacea*, Rehm, on the sandhills, Formby, April 1907, spec. named by H. Sandstede ; also on railway-banks, Walton, Liverpool, and sand-dunes near Ainsdale, amongst *Dicranum scoparium* var. *orthophyllum*.

CLADONIA CÆSPITITIA, Floerke. On heathy ground, in the crevices of mossy walls, and on dry banks in the sand-dunes. Not common.

Freshfield ; old delph at Kirkby, 1907 ; Boulsworth Moor, Sept. 1910, *A. Wilson* ; old walls, Little Crosby ; roadside walls between Aintree and Maghull, Oct. 1910 ; Formby sandhills, *c. frt.*, Feb. 1912 ; crevices of mossy limestone walls, Chatburn, March 1913.

CLADONIA COCCIFERA, Schaer. Not uncommon on heathy, peaty ground and banks in the upland moors; rare in the lowland. Usually only poorly developed with us. Fruiting occasionally.

Dick Hill, Butterworth, *Dr. Buckley MS.* (1); between Barrowford and Barley Moor, *A. Wilson*; summit plateau of Pendle Hill, 1700–1800 ft.; Withnell Moor, *G. H. Hopley*!; Worsaw Hill, Chatburn; Boulsworth Hill, *H. Robinson*! Old sandstone delph, Kirkby, and in sandy fields near Mere Brow near Banks.

CLADONIA DIGITATA, Hoffm. Very rare, or perhaps overlooked. Sterile.

Whitworth, herb. *Molineux* (specimen not seen by us); Easden Clough near Burnley, Nov. 1912, *C. R. Ritchings*!

CLADONIA FLABELLIFORMIS (Floerke), Wainio.

f. SCABRIUSCULA (Del.), Wainio. Railway-banks near Walton, Liverpool. On large blocks of sandstone sunk in the banks.

CLADONIA MACILENTA, Hoffm.

On peaty banks and on rotten wood. Not uncommon, especially in the hilly districts. Occasionally met with in fruit near Barrowford, *A. Wilson*; *c. frt.*, Blacko, *H. Robinson*!; Withnell Moor, June 1910, *G. H. Hopley* & *W. G. T.*; Hartshead, near Mossley, *W. Watson*; Saucer Stones, Boulsworth Hill, *H. Robinson*! Summit of Pendle Hill; Worsaw Hill, Chatburn. The var. *squamigera* and f. *clavata* on peaty banks on moorland about Rainford, and inland "moss" near Freshfield.

CLADONIA BACILLARIS, Nyl. *ex* Cromb.

On peaty moorland in the hills. Rare. Crompton Moor, *W. Watson*!

CLADONIA FLOERKEANA, Fr., f. TRACHYPODA, Nyl.

Withnell Fold near Chorley, 1911, fruiting, *G. H. Hopley*!

CLADINA SYLVATICA, Nyl. "Reindeer Moss."

Moorlands in the hilly districts and moist mossy hollows in the sand-dunes of the coast. Very rare, if not now extinct, in our upland districts; locally on the dunes, as at Formby, Ainsdale, and Freshfield. Sterile.

The following old records *sub nom. C. rangiferina*, Nyl., doubtless belong here:—Rush Hill, near Rochdale, *Dr. Buckley*; Rooley Moor, herb. *Molineux*; Forest of Rossendale, *Stansfield*.

CLADINA UNCIALIS, Nyl. Very rare. Sterile.

(Rush Hill, near Rochdale), *Dr. Buckley MS.*; peaty ground on Pendle Hill, at 1300 ft., May 1910.

LECIDEACEÆ.

GYALECTA CUPULARIS, Schaer. (*Lecidea marmoreus*, With.)

Plentiful on decayed moss on the mortar of an old limestone wall, Downham, May 1910 ; also on shady, damp limestone rocks, Worsaw Hill, Chatburn ; probably not uncommon in that neighbourhood.

This lichen rarely occurs on any substratum except bare rock, and in regard to the first-named locality, it may be mentioned that there is a variety growing in such situations on the Continent which is distinguished by its paler apothecia with entire border and known as var. *marmorea*, Ach. Our specimens from Downham agree very well with this variety, which has not hitherto been described as British.

LECIDEA LURIDA, Ach.

On earth among limestone rocks. With us this species is limited to the limestone area in the Ribble Valley, and is not uncommon in the quarries and on rock outcrops about Clitheroe and Chatburn.

LECIDEA LUCIDA, Ach.

On sandstone rocks and walls. Rare. Sterile. "First noticed by Sir J. E. Smith [in 1804], growing on hard sandstone rocks about Liverpool," *Eng. Bot.* 2nd ed. (1846), vol. x. p. 77 ; *cf.* op. cit. ed. 1, t. 1550 (1806) ; on walls of Carboniferous sandstone, Billinge Hill, May 18 ,1912.

LECIDEA GAGEI, A. L. Sm.

On Millstone Grit walls near the golf-links, Colne, Dec. 1913, *H. Robinson* ! Recorded by us in Lanc. Naturalist, Dec. 1913.

LECIDEA COARCTATA, Nyl. On rocks and walls. The type is apparently rare.

On calcareous rocks in a stream course, Lane Head, near Downham ; occurred along with the var. *elacista* on lumps of sandstone on an old colliery refuse-heap, Reeds Moss, Rainford, July 1914.

Var. ELACISTA, Cromb. Kerbstones of road between Aintree and Ford, 1907 ; sandstone walls along the road between Aintree and Maghull, Oct. 1910 ; on stones, Sheddon Clough, near Burnley, May 1912 ; in good condition on roadside kerbs between Halebank station and Hale, May 24, 1913 ; shaly rocks, Hey Slacks Clough, Walverden Valley, *H. Robinson* ! The f. *cotaria*, Cromb., on the sandstone copings of a brick wall near the shore, Freshfield, May 1914.

Var. ARGILLISEDA, Boist. On earth and moss in the crevices of an old sandstone wall between Aintree and Maghull, Oct. 1910, *Rept. Lichen Exchange Club*, 1911, p. 17.

LECIDEA GRANULOSA, Schaer. (*L. decolorans*, Floerke.)

On bare, peaty ground in the hilly districts. Locally common in some of our moorland areas.

Summit of Pendle Hill; Waterhead, March 1909, *W. Watson*! Peaty banks, Black Hill, Sabden, May 1912; Withnell Moor, *G. H. Hopley*! Noyna, near Colne. On railway-banks, Walton, Liverpool.

f. VIRIDULA, Cromb. Summit of Boulsworth Hill, May 1912.

LECIDEA ULIGINOSA, Ach. On bare peat, and on thin dry humus on sandy ground. On the deep, pure peat of the moors it is often associated with the next preceding species. It is not restricted to true peat, as it occurs also on thin humus, such as the decaying leaves of Marram grass and mosses on the dunes, more especially on the shady sides. Frequent, and ranging from sea-level up to the summit of Pendle Hill, 1830 ft.

Var. HUMOSA, Ach. On bare, clayey soil in a sandstone quarry, Little Crosby, Aug. 12; also on bare spots on boulder-clay banks of R. Mersey at Hale, Aug. 1912.

LECIDEA FULIGINEA, Ach. On old stumps; probably more frequent than the single record indicates.

On an old decaying log on the sandhills, Formby, Jan. 14 (sterile).

LECIDEA ATROFUSCA, Mudd.

On mortar of an old wall, Watermeetings, near Colne, May 1913, *H. Robinson & W. G. T.*

LECIDEA IMMERSA, Ach. (*L. calcivora*, Ehrh.)

On limestone rocks near Chatburn Station, March 1907, *A. A. Dallmann & J. A. W.*

LECIDEA OCHRACEA, Wedd.

On argillaceous limestone rock in a gully above Hook Cliffe, Pendle Hill, alt. 750 ft., June 1913.

LECIDEA PROTRUSA, Fr.

On old bricks on a colliery refuse-heap, Reeds Moss, Rainford, July 1914.

LECIDEA PLEIOSPORA, A. L. Sm.

On decaying moss and scanty humus, sand-dunes, Freshfield, April 1912, *teste* Miss A. L. Smith; collected again in the same locality, April 1914, and it is probably not rare in the dunes on the right kind of ground; on the ground, Belmont, near Rivington, June 1912, *A. Wilson*!

This lichen was discovered by the Rev. H. P. Reader, in 1910, on the soil of a disused clay-pit at Little Bowden, Northants, and described and figured by Miss Smith as a new species in Journ. Bot. xlix. (1911), p. 41. We had described in MS. our Freshfield plant as a new species, but on sending it to Miss Smith, she pointed out

that this lichen had been already described by her under the above name, and was included in the addenda to Mon. Brit. Lichens, vol. ii. p. 352.

The discovery of this species in Lancashire is of interest, as we understand that the clay-pit in which Father Reader discovered it has been filled in and the habitat destroyed.

LECIDEA PARASEMA, Ach. On the bark of trees and on decaying wood. Rare, and poorly developed.

Rainford, *Vict. Hist.* p. 85 ; stumps on the shore, Banks; on willows, Woodvale, July 26, 1913 ; near Downham, June 1914, *C. B. Travis & W. G. T.*

Var. ELÆOCHROMA, Ach. (*L. enteroleuca*, Ach.)

On a piece of old pine-bark, sandhills, Formby, April 1913 ; on the bark of a holly-tree near Downham, June 1914, associated with *Pertusaria leioplaca*, Schaer.

LECIDEA GONIOPHILA, Schaer.

Occurred, along with *Lecanora galactina*, on a half-buried stone (limestone) in a footpath near Cock Bridge, Whalley, March 1913, *C. B. Travis & W. G. T.*

LECIDEA CONTIGUA, Fr. On rocks and walls of Millstone Grit and sandstone; common, especially in the hilly districts, but occurring also, not unfrequently, on sandstone walls in the lowland. It is very noticeable on and by water-washed rock-surfaces in the cloughs. Only observed by us on siliceous rocks. This species, judging by its frequency and its occurrence often close to towns, is fairly tolerant of a smoky atmosphere.

LECIDEA SOREDIZA, Nyl. Very rare. Sterile.

On chert, in a small clough or gully above Hook Cliffe, Pendle Hill, alt. 700 ft., June 1911.

LECIDEA CRUSTULATA, Koerb. On sandstone rocks and loose stones. Probably not uncommon in the upland districts.

Boulsworth Moor, Sept. 1910, *A. Wilson* ! Pendle Hill, alt. 700 ft., June 1911; Greens Clough, May 1912, *C. R. Ritchings & W. G. T.*; on a half-buried stone in a field, Chatburn, March 1913; Cold Wells near Burnley, and on a sandstone wall, Watermeetings near Colne, May 1913, *H. Robinson & W. G. T.*; on clay ironstone nodules on old colliery rubbish heaps, near Rainford, July 1914.

Var. MEIOSPORA, Olivier. Sandstone wall, Aintree, Feb. 1904.

[LECIDEA CONFLUENS, Ach.

Forest of Rossendale, *A. Stansfield*.]

We have not ourselves seen this species in our area, and its occurrence now is problematical.

LECIDEA LITHOPHILA, Ach.

Very fine, on water-washed stones and boulders in the stream, Sheddon Clough, near Burnley, May 1912. It was associated with *L. contigua*, Fr.

LECIDEA PLANA, Nyl.

On the sandstone coping-stones of a bridge at Twiston, June 1914.

LECIDEA EXPANSA, Nyl.

On half-buried stones (limestone) in banks of glacial drift by the River Ribble, at Chatburn, March 1913. Associated with *Verrucaria submersa*, Schaer.

LECIDEA SANGUINARIA, Ach. On rocks only with us, although it occurs on bark also north of the Ribble beyond our area. Very rare.

On sandstone rock, Clark Hill, Whalley, June 1908.

BIATORELLA MORIFORMIS, Th. Fr.

On an old stump on the sandhills between Freshfield and Ainsdale, July 1914.

BIATORELLA CAMPESTRIS, Th. Fr.

On bare, damp, sandy ground, encrusting decaying mosses and hepatics, sandhills between Freshfield and Ainsdale, Nov. 1912.

This species has only once previously been recorded as having been collected in Britain, namely at Braunton Beacon, Devon, by Mr. E. M. Holmes, see Addenda, Mon. Brit. Lichens, vol. ii. p. 353. It is a beautiful little species, only to be found by very close search; the small apothecia being very scattered and having the appearance of a minute discomycetous fungus.

BIATORINA CŒRULEONIGRICANS, A. L. Sm.

Not infrequent on the ground among and in crevices of limestone rocks; occurs also, but rarely, on calcareous (shelly) sand on the coastal dunes.

Sandhills at Formby, very sparingly, 1892; near Chatburn, *A. A. Dallman & J. A. W.*; Worsaw Hill, Chatburn, May 1910.

BIATORINA GRANIFORMIS, A. L. Sm. (*Lecidea Ehrhartiana*, Ach.) On the bark of trees. Very rare. Sterile, but with abundant spermogones.

On a hawthorn, by the R. Ribble, near Clitheroe, June 1912; on the bark of an elm at the mouth of Chatburn brook, Chatburn, June 1914.

BIATORINA LENTICULARIS, Koerb. On calcareous rocks and stones, also on mortar. Rare.

On shady, damp limestone rocks, Worsaw Hill, Chatburn, Sept. 1910; on mortar in an old wall near Hacking Boat, March 1913, *C. B. Travis & W. G. T.*

f. NIGRICANS, Arnold. On a half-buried stone (limestone) in a bank by the railway near Ings Beck, near Downham, Aug. 1913. On clay ironstone nodules on an old colliery refuse-heap near Rainford, July 1914.

BIATORINA CHALYBEIA, Mudd.
On calcareous shaly rocks in a gully above Hook Cliffe, Pendle Hill, June 1911.

BILIMBIA AROMATICA, Jatta.
On earth among shady limestone rocks, Worsaw Hill, Chatburn, Sept. 1910; in the crevices of a limestone wall, Downham, March 1913 and June 1914; on mortar of a bridge on the Cheshire Lines Railway, near Woodvale Station, Aug. 1914.

BILIMBIA SQUAMULOSA, A. L. Sm.
On damp, sandy, mossy ground among the sandhills, near Freshfield, 1908, and in Oct. 1910.

BILIMBIA SPHÆROIDES, Koerb.
Not infrequent on decaying mosses and scanty humus on the bare firm surface of fixed dunes, and has been met with on several occasions at Birkdale, Formby, and Freshfield. On bark at the base of a tree by R. Ribble, at the mouth of Chatburn brook, March 1913.

BILIMBIA SABULETORUM, Branth & Rostr.
Encrusting decaying moss, in the crevices of a mortared wall, Huntroyd Park, near Padiham, May 25, 1912; on earthy banks, Pendle Water, Watermeetings, near Colne, May 1913, *H. Robinson & W. G. T.*; in the crevices of a limestone wall, Worsaw Hill, Chatburn, March 1913.

BILIMBIA SUBVIRIDESCENS, A. L. Sm., var. TRISEPTA, A. L. Sm.
On the ground and on decaying mosses, in a gully above Hook Cliffe, Pendle Hill, alt. *circa* 700 ft., June 1911.

BILIMBIA LIGNARIA, Massal. (*B. milliaria*, Koerb.)
On mosses and earth in limestone rocks, Worsaw Hill, Chatburn, May 1910; in the crevices of a limestone wall, Chatburn, March 1913. A saxicole form, which may be f. *saxigena*, A. L. Sm., occurs on the sandstone coping of a brick wall by the road leading to the shore at Freshfield, May 1914.

BACIDIA PHACODES, Koerb. (*Lecidea chlorotica*, Nyl., *L. luteola*, var. *chlorotica*, Ach.)
On pieces of old leather lying on the sand-dunes near Freshfield, 1913. The specimens had yellowish apothecia, the tinge of rose present in them when fresh soon fading; thallus pulverulent, green; hypo-

thecium colourless; spores 27–42 × 1–2 μ. The plants were well developed, with the apothecia abundant, and probably belonged to the f. *intermedia*, Hepp.

Occurred again on old leather in the same locality, May 1914, and in association with the next following species.

It is of interest to note that Sandstede (**18**) has also recorded this species as occurring on the same substratum and in the same kind of habitat, namely on old leather lying about in the dunes in the East Friesian Islands; and it may be added that our examples collected in May 1914 appear to agree well with those of a form he mentions having small, reddish-brown apothecia "zu Gruppen gehäuft." A similar form was found by one of us, with Mr. J. W. Hartley, on the same matrix on the Manx sand-dunes.

BACIDIA EFFUSA, Arnold.

On old leather lying in the sand-dunes near Freshfield, May 1913.

The apothecia were often discoloured by a mould, the dark mycelium of which had penetrated the hymenium.

BACIDIA LATEBRICOLA nobis, spec. nov.

Thallus viridi-flavescens, granuloso-leprosus, effusus, K— C—. *Apothecia* minuta, primo carnea, deinde livida et ætate nigricantia; epithecium incolor; hypothecium fere incolor; hymenium incolor, iodo vinosum, haud primo cœrulescens. *Asci* cylindrico-clavati, 35–45 μ longi. *Paraphyses* clavatæ. *Spori* anguste lineari-clavati, plerumque uno polo obtusi, altero attenuati, varie curvi, rare recti, gracillimi, 5–11-septati, septis tenuibus 26–43 μ × 1–2 (ubi latissimi).

The thallus resembles that of *B. effusa*, Arnold, from which it differs in the reaction of the hymenium with iodine, and in the shorter spores, and habitat. From *B. herbarum*, Arnold, to which it is also allied, it differs in the colour of the thallus, smaller apothecia, reaction of the hymenia with I, and the more clavate paraphyses. From *B. arceutina* var. *hypnæa*, A. L. Sm., it differs in the smaller, more strongly flexuose spores, in the colour of the thallus and apothecia, and colour of epithecium, as well as the reaction of the hymenium with iodine. Apothecia are only very sparingly produced.

Hab. Creeping over decayed mosses and thin dry humus on broken sandy banks overhung by herbage. Sandhills at Formby, April 14, 1913; Freshfield, May 1914. Type spec. in herb. *Wheldon & Travis.*

BACIDIA ARCEUTINA, Branth & Rostr. The type is not known to occur in South Lancashire, but the following variety has been met with.

Var. BREVISPORA nobis, var. nov.

Thallus granulosus, ob hypothallum nigrum præcipuum obscure cinerascens. *Apothecia* primo plana, mox admodum convexa, margine obliterato, novella levissime fuscescentia, cito nigra. *Hypothecium*

incolor vel ubi excipulo nigricanti contiguum vestigio flavi coloris tinctum ; epithecium et sæpe etiam hymenium solida, pallide fuliginosa, in plagas tenues dissecta fere incoloria. *Spori* 25–38 × 1·2–2·5 μ, septis valde obscuris plerumque 7, raro recti, sæpe curvi et haud infrequenter sigmoidei, implexi in asco.

Hab. Incrusting decaying mosses on the sand-dunes at Freshfield, April 1914. Type spec. in herb. *Travis*.

Differs from the type in the shorter, more strongly curved spores, and the habitat. The var. *hypnæa*, A. L. Sm., grows on moss on rocks, and has spores still longer than in the type.

BACIDIA SALICICOLA nobis, spec. nov.

Thallus parcus vel evanescens. *Apothecia* e rubello ad nigrum variantia subminuta, mox immarginata. *Hypothecium* incolor ; epithecium brunneum. *Spori* 29–35 × 2–3·5 μ, uno polo sæpe attenuati, nunc cylindrici, nunc fusiformes, plerumque incurvi. *Gelatina* hymenii iodo cærulea, deinde tarde in vinosum abiens.

Differs essentially from *B. arceutina*, Branth & Rostr., in its shorter, stouter spores, and smaller apothecia ; approaches in these characters to *B. Beckhausii*, Koerb., but differs from that in the spores being often acute at one or both ends, in the brighter coloured apothecia, and colour of the epithecium.

Hab. On dead twigs and exposed underground stems of *Salix repens* on the coastal sandhills. First collected at Formby, April 14, 1913, since seen at Ainsdale and Freshfield, and is probably not uncommon all over the dune tract. It has also subsequently been collected once on pine-bark near Ainsdale.

BACIDIA EPIPHYLLA nobis, spec. nov.

Thallus fere evanescens, e granulis paucis virescentibus exsiccando cinereis consistens. *Apothecia* admodum minuta, nigra, sessilia, plana, deinde convexa, mox immarginata, intus incoloria. *Epithecium* pallide fuscum. *Paraphyses* clavatæ, plerumque apice incolores, levissime cohærentes. *Hypothecium* pallide flavido-fuscum. *Hymenium* perpallidum, iodo viridi-cœruleum, mox saturate vinosum. *Asci* tenues, 47 μ longi. *Spori* tenuiter aciculares, uno polo sæpe curvi, multiseptati, 33–45 × 1–2 μ.

This very minute and inconspicuous species is distinguished from allied species by its very minute apothecia, less conglutinate paraphyses, and habitat on dead leaves. Its nearest relation from which it may be derived is *B. arceutina*, Branth & Rostr., from which it is easily separated by its smaller apothecia without red tinge, shorter spores, and peculiar habitat. *B. Beckhausii* has shorter spores and different paraphyses, more coloured and conglutinate.

Hab. On fallen leaves of *Salix repens* on the sand-dunes near Ainsdale, Dec. 1913.

BACIDIA BECKHAUSII, Koerb. On bark. Very rare.

On a piece of old bark lying on the sandhills, Freshfield, Sept. 1908; on the bark of *Pinus maritima* on the sandhills, Freshfield, May 1914.

BACIDIA MUSCORUM, Mudd. On mosses on limestone rocks and sand-dunes.

Incrusting mosses on a small limestone scar by the roadside between Chatburn and Worston, 1907, *A. A. Dallman & J. A. W.*; sandhills, Formby, March 1912; in the crevices of limestone rocks, Worsaw Hill, March 1913, *C. B. Travis & W. G. T.*

Var. ATRISEDA nobis, var. nov.

Thallus effusus, granulosus, granulis vegetis acriter viridibus siccatis cinereis, in hypothallo nigricante sparsi. *Apothecia* primo pallide cervina, mox nigra, exsiccando semper nigra, margine tenui, mox immarginata, demum valde convexia et deformia, solitaria vel aggregata. *Epithecium* nigricans; hymenium fuscescens; hypothecium saturate rubro-fuscum. *Spori* recti vel leviter curvati, uno vel utroque polo acuti, interdum caudati, 30–39 × 2–3 μ. KHO et I reactiones ut in typo.

Hab. On decaying mosses and thin, moist humus on bare low *Salix repens* dunes, associated with *Cladonia pyxidata.* Formby, Oct. 1907, Jan. 1914.

Forming blackish patches owing to the predominant dark substratum on which the thalline granules are sparsely scattered. Differs from the type in its colour, dusky hymenium, apothecia, and habitat, and may prove to be a distinct subspecies.

BUELLIA CANESCENS, De Not. Not infrequent locally. Sterile.

Kerbstones of a footpath near Netherton, Jan. 1910; abundant in that situation, but thalli small and ill-developed; at the base of sandstone walls of a barn, Little Crosby, Sept. 1912; common on limestone walls at the outskirts of Downham village, March 1913; also seen on limestone gate-posts in other localities in the vicinity of Chatburn and Downham; on the bark of roadside trees near Smithies Bridge, Chatburn.

BUELLIA MYRIOCARPA, Mudd.

On the bark of a roadside tree in a lane close to Horrocksford Bridge, Clitheroe, March 1913; on a log on the sandhills near Freshfield, 1913; the var. *punctiformis*, Mudd, abundantly on a prostrate tree-trunk on the shore near Hale Point, May 24, 1913; on dead willow-twigs on the sandhills, Formby, March 1914; on a roadside tree near Smithies Bridge, Chatburn, June 1914.

[BUELLIA PARMELIARUM, H. Olivier. (*Abrothallus Smithii*, Tul.)

This lichen (or fungus), which is parasitic on the thalli of various foliaceous lichens, was first detected in South Lancashire, namely, on Emmott Moor, near Colne, on *Platysma glaucum*, Nyl., *q. v.*]

Rhizocarpon petræum, Massal. (*Lecidea concentrica*, Leight.)

On rocks and walls, both calcareous and siliceous. Rare. (On a wall between Broad Green and Roby), *F. P. Marrat*; rocks in a gully, N.W. side of Pendle Hill, alt. *circa* 700 ft., June 1911; walls of Coal Measure sandstone, by Pimbo Bushes, Billinge Hill, May 18, 1912; on gritstone rocks and boulders in stream, Ogden Clough, Pendle Hill, Aug. 1913; on clay ironstone nodules on an old colliery refuse-heap, Reeds Moss, Rainford, July 1914.

Var. excentricum, A. L. Sm. On limestone and on calcite crystals, Bold Venture Quarry, Chatburn, Aug. 1913.

Rhizocarpon confervoides, DC. (*Lecidea petræa*, Tayl.)

On shaly, calcareous rocks in a gully, N.W. side of Pendle Hill, alt. 700 ft., June 1911; on sandstone blocks at the base of the landmark, Freshfield, 1913; f. *coracinum*, Flot., on the horizontal surfaces of Coal-Measure sandstone, Greens Clough, near Todmorden, May 1912.

GRAPHIDACEÆ.

Opegrapha saxicola, Ach.

Damp, shady limestone rocks, Worsaw Hill, near Chatburn, Sept. 1910; limestone wall near Worston, March 1913.

[Graphis scripta, Ach.

Forest of Rossendale, *A. Stansfield.*]

Extinct.

DERMATOCARPACEÆ.

Dermatocarpon lachneum, A. L. Sm. (*Endocarpon rufescens*, Ach.)

On earth among limestone rocks. Near Clitheroe, 1906; near Chatburn, 1907, *A. A. Dallman & J. A. W.*; on top of Worsaw Hill, Chatburn, April 1913.

VERRUCARIACEÆ.

Verrucaria maura, Wahl.

Very sparingly, on sandstone rocks at tide-level, Hale Point, May 24, 1913.

Verrucaria aquatilis, Mudd.

On stones in the bed of R. Ribble, near Clitheroe, June 8, 1912.

VERRUCARIA MARGACEA, Wahl.

On sandstone rocks in stream, Hey Slacks Clough, Walverden Valley, May 1913.

VERRUCARIA ÆTHIOBOLA, Wahl.

On submerged stones (black calcareous shales) in the bed of R. Ribble at Chatburn, June 1911.

VERRUCARIA SUBMERSA, Schaer.

On half-buried stones (limestone) in banks of glacial drift by the R. Ribble at Chatburn, March 1913. On damp, shady limestone rocks in an old quarry, Chatburn, June 1914.

VERRUCARIA PAPILLOSA, Ach.

On calcareous stones by the R. Ribble near Clitheroe, June 1912; on shady, damp limestone rocks, Bold Venture Quarry, Chatburn, March 1913, *C. B. Travis & W. G. T.*

VERRUCARIA VIRIDULA, Ach.

On walls by the R. Ribble near Clitheroe, June 1912.

VERRUCARIA NIGRESCENS, Pers.

On bare exposed limestone rocks, Worsaw Hill, June 1911; on mortar, Horrocksford Bridge near Clitheroe, March 1913; very sparingly on cement at the landmark, Freshfield, 1913; on pieces of limestone on a railway-bank at Walton, Liverpool, July 1914.

VERRUCARIA MAUROIDES, Schaer.

On exposed limestone rocks at the top of Worsaw Hill, Chatburn, Sept. 1910.

VERRUCARIA MACULIFORMIS, Krempelh.

On limestone rocks in a gully near Hooke Cliffe, Pendle Hill, alt. 750 ft., June 1911; on black calcareous shale, Horrocksford Quarries, Clitheroe, March 1913. In the latter locality fairly common on pieces of black shale lying about in the older parts of the quarries; but the lichen is not easy to discern owing to the dark colour of the substratum.

VERRUCARIA DUFOURII, DC.

On shady, bare limestone rocks, Worsaw Hill, Chatburn, Sept. 1910.

VERRUCARIA MURALIS, Ach. On the mortar of walls and bridges. Probably more frequent than our records would indicate.

Chatburn, 1907; in several places near Maghull, May 1910; Brinscall, June 1910, *G. H. Hopley & W. G. T.*; on cement at the landmark, Freshfield, 1913; on mortar of a wall by Horrocksford Bridge, Clitheroe, 1913.

VERRUCARIA RUPESTRIS, Schrad.

On bare limestone rocks and the mortar of walls. Worsaw Hill, Chatburn, May 1910; on limestone and calcite crystals, Bold Venture Quarries, Chatburn, March 1913.

Var. SUBALBICANS, Mudd. On the mortar of a wall, Little Crosby, June 1910; Horrocksford Bridge, near Clitheroe, March 1913.

VERRUCARIA INTEGRA, Carroll.

Occurred, along with *Biatorina lenticularis*, Koerb., on mortar in a limestone wall near Hacking Boat on the R. Ribble, March 1913, *C. B. Travis & W. G. T.*

VERRUCARIA CALCISEDA, DC.

On bare, exposed limestone rocks at the top of Worsaw Hill, Chatburn, May 1910.

THELIDIUM MESOTROPUM, A. L. Sm.

On half-buried stones (limestone) in banks of glacial drift by the R. Ribble at Chatburn, March 1913.

THELIDIUM MICROCARPUM, A. L. Sm.

On pieces of mortar on a broken-down wall, Sandy Lane, Fazackerley, Dec. 1911 and April 1912; also in a similar habitat at Ford, April 1912.

THELIDIUM INCAVATUM, Mudd.

On the mortar of a wall, Chatburn, March 1913.

MICROGLÆNA NUDA nobis, spec. nov.

Thallus obsoletus vel ad granulas paucas cinereas ad apotheciorum bases sitas reductus. *Perithecia* minuta, nigra, superficiaria, dimidiata, ostiolo poro distincto potius depresso. *Paraphyses* subpersistentes, visibiles quoad spori omnino evoluti sunt, ramosi, tenues. *Asci* subcylindrici. *Spori* 8, irregulariter in ascis distributi, 2–3-septati, tardissime parce longitudinaliter septati, incolores vel pallide virides, oblongo-ellipsoidei, utrinque obtusi, cellulis magnitudine et forma irregularibus, $16–20 \times 6–7{\cdot}5\ \mu$.

Hab. On half-buried gritstone pebbles in glacial drift on the banks of the R. Ribble at Chatburn, March 1913. Type-specimen in herb. *Travis.*

STAUROTHELE HYMENOGONIA, A. Zahlbr. On the mortar of walls; sometimes associated with *Verrucaria muralis*, Ach. Rare.

Maghull; Brinscall; and near Clitheroe.

PYRENULACEÆ.

ACROCORDIA GEMMATA, Koerb. (*Verrucaria gemmata*, Ach.) On the bark of trees in subalpine districts.

On trees near Clitheroe.

ACROCORDIA EPIPOLÆA, A. L. Sm. (*V. conoidea*, Fr.)

On limestone rocks, Worsaw Hill, Chatburn, March 1913.

ARTHOPYRENIA ARENISEDA, A. L. Sm.

On the ground in bare moist "slacks" amongst the sandhills. It has been noted at various points in the dunes along the South Lancashire coast, from Formby to Birkdale; and it has also been found by one of us on the Cheshire coast near Hoylake, see Repts. Lichen Ex. Club, 1909–1911.

This lichen, which is only yet known in the limited area above mentioned, first came under observation by one of us in 1905–1906; and specimens were distributed through the Lichen Exchange Club of the British Isles in the years 1909 and 1910. It was described as a new species by Miss A. L. Smith in Journ. Bot. (1911), pp. 42–43, t. 510. f. 5; see also Mon. Brit. Lichens, ii. 323 & 324. The original description may, perhaps, here be conveniently quoted :—

"Thallus albido-cinereus, continuus, granulosus, leviter furfuraceus. Perithecia minuta, nigra, semi-immersa, subglobosa, integra, ostiolo lato notata; paraphysibus numerosis, gracilibus, ramosis; ascis elongatis, utrinque angustatis, circa 0·140 mm. longis, 0·025 mm. latis; sporis normaliter octonis, elongato-clavatis, sursum latioribus, interdum guttulatis, hyalinis, 1-septatis, majusculis, 0·032–37 mm. longis, 0·010 mm. latis.

Ad litora humida arenacea.

Collected at Formby, Lancashire, by Mr. J. A. Wheldon in spring. The thin grey thallus follows the inequalities of the substratum. The scanty algal symbiont, *Trentepohlia*, has the deep yellow colour of the gonidia characteristic of many maritime species. The perithecia are few and inconspicuous; the spores resemble in form those of *A. epidermidis*, but they are much larger."

This species will be readily found in the localities mentioned, if looked for on the right type of ground, but will be sought in vain elsewhere on the dunes. The ground which it favours is in the bare dune-valleys and open expanses in the wetter parts of growing or mobile

dunes, where the soil is permanently moist. The surface of this bare, damp soil rapidly becomes crusted over by the deposition of fine sedimentary matter and the growth of algæ, and is soon occupied by small mosses and creeping hepatics. It is whilst the ground is in this condition that *Arthopyrenia areniseda* occurs, and *in situ*, when moist, the lichen resembles a dirty-white incrustation on the soil, and, when dry, looks much like a greyish efflorescence.

It has been found fruiting freely on a few occasions; but usually the perithecia are scarce and require careful search. Spores have been found ranging up to $45 \times 15\,\mu$.

[ARTHOPYRENIA EPIDERMIDIS, Th. Fr.
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Cryptogams from the Falkland Islands collected by Mrs. Vallentin, and described by A. D. Cotton, F.L.S.

(Plates 4–10.)

[Read 5th November, 1914.]

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PREFACE.

So far as flowering plants and ferns are concerned, the flora of the Falkland Islands may now be said to be thoroughly known. An account by Mr. C. H. Wright was published three years ago in the 'Journal of the Linnean Society,' his paper being the outcome of the study of extensive collections made by Mrs. Elinor Vallentin in 1898 and 1899 and presented to Kew a short time previously. With a view to making his account as complete as possible, Wright examined the older collections and incorporated previous records, and, by giving data as to localities and collectors, showed some of the changes which had taken place since the publication of the 'Flora Antarctica.' Since the appearance of his paper, a memoir on the same subject has been published by Skottsberg, who, in addition, describes the vegetation from an ecological standpoint.

When Mrs. Vallentin was about to return to the Falkland Islands in 1909, it was suggested to her that the cryptogamic flora would well repay investigation. Nothing of importance had been added to the Kew collections since the magnificent series collected by Hooker in 1842 and described in the 'Flora Antarctica,' and, though our knowledge of the lower plants had since then largely increased, scarcely a paper in which the cryptogams of the Falkland Islands were included had appeared. Mrs. Vallentin readily assented. An account of her collections of marine algæ, lichens, and fungi is set forth below, the mosses and hepatics being dealt with by Mr. Wright in a separate paper.

INTRODUCTION.

The present paper is divided into three main sections, dealing with the marine algæ, lichens, and fungi respectively. So far as the purely systematic work is concerned, each section is complete in itself, but in preparing the historical sketch, and in considering the geographical relationships of the flora, it was more convenient to treat all the cellular cryptogams together. These two subjects, therefore, and also some floristic notes, are dealt with in a special section, before the general systematic account, entitled "The Cryptogamic Flora."

In the three sections referred to, not only are Mrs. Vallentin's plants enumerated, but also, as far as possible, all previous records. Each section therefore forms a complete list of the known flora of the group in question. With regard to the algæ, the value of the list is increased by a considerable amount of critical work which it has been possible to include. In the case of the lichens, time did not permit of research of this kind, hence most of the older records have been accepted without question; and in the third group—the fungi—there was little previous work to revise. To make the series complete, a list has been compiled of the fresh-water algæ known from the islands.

1. Mrs. Vallentin's Collections.

The collections made by Mrs. Vallentin in 1909–1911 are entirely from the western islands, an area of the Falklands which, so far as cryptogamic botany is concerned, had been practically unexplored. Of the three groups of plants dealt with in the present paper, the marine algæ figure most largely, some 400 herbarium specimens having been mounted. The lichens follow; these, being dried without pressure and packed in boxes, arrived in good condition and, being accompanied by coloured drawings, form excellent material for museum or exhibition purposes. But it was to the fungus flora, hitherto almost unknown, that Mrs. Vallentin paid special attention. Some fifty species were collected. In the case of the Agarics, great care was taken and coloured drawings accompanied the spirit or formalin material

Thanks to careful packing, the material arrived in a good state of preservation and several very interesting plants have been recorded. The Agarics, however, proved exceedingly difficult to determine with any degree of certainty, and it was with great regret that not a few of the delicate species of this group had to be left unnamed. The series of coloured drawings will eventually be incorporated in the Kew collections, and will be available for future reference.

The results obtained from the above collections are dealt with in detail in the respective sections—suffice it to say here that, apart from the value of the collections as such, they have provided several new species and a number of new records, and incidently led to the clearing up of various questions of systematic and geographical importance.

Mrs. Vallentin writes as follows with regard to help received from friends in the Falklands :—

"My grateful thanks for assistance and help are due to His Excellency The Governor of the Falklands and Mrs. Allardyce, also to W. H. Harding, Esquire, and W. C. Girling, Esquire, both of the Falkland Islands Co., and to Mr. and Mrs. Vere Packe and Mrs. O. Dean, all of Stanley. To Messrs. Homstead and Blake and to their courteous manager, Mr. Sydney Miller, and Mrs. Miller, through whose hospitality and kindness we were able to reside at Hill Cove and Shallow Bay and add considerably to our collections. From Mr. and Mrs. Benney, Mr. and Mrs. Buckworth of West Falklands, we also received much help. For valuable specimens added to my collections of algæ my acknowledgments are due to Mrs. Halliday of West Point Island, and to Miss Harriet Goodwin of Shallow Bay. Lastly, to my husband, Mr. R. Vallentin, for his valuable care and advice in the management and transport of my collections."

2. Notes on the Collecting-ground and Vegetation.

The following notes by Mrs. Vallentin indicate the areas from which the collections, especially those of the algæ, were obtained, and they give at the same time a clear idea of the vegetation in general :—

"The Falkland archipelago, the largest cluster of islands in the South Atlantic, lies approximately between 51° 15′–52° 30′ S. lat. and 57° 40′–62° 25′ W. long., and about 350 miles N.W. of the Straits of Magellan. Speaking generally, they occupy the same position in the southern hemisphere that Great Britain does in the northern. They consist of East Falklands (area 3000 square miles) and the West Falklands (2300 square miles), and numerous islands and islets, totalling about 7000 square miles. Mount Adam, the highest peak, 2360 ft., is located on the western island and, being near our headquarters, was carefully explored. This range culminates on West Point Island with its stupendous cliffs 1200 feet in height. The

Wickham Heights run almost due east and west across the East Island, the highest peak being Mount Usborne, 2245 feet. The climate is bleak and the penetrating power of the wind extraordinary; but the temperature is fairly equable, ranging from 19° F.–42° F. in winter and from 34° F.–72° F. in summer.

"Up to comparatively recent times the descendants of the cattle landed by Bougainville on the East Island and those landed by sealers and others on the Western Island rambled everywhere, but, owing to their comparatively small numbers, they did not appreciably affect the flora. About the year 1867 sheep were introduced, and with them came Scotch shepherds. With their régime a rapid change took place over the whole archipelago and wholesale burning of the 'heather' (*Empetrum rubrum*) and grasses followed every spring-time.

"When the late Mr. W. W. Bertrand first settled on the West Falklands the grass on the plains was waist deep, and whole flocks of sheep would disappear into hidden brooks and streams which were effectually concealed by this rank vegetation. Darwin's statement ('More Letters,' vol. i. p. 380) that the 'struggle for existence of plants with hostile animals is of supreme importance' is very plainly illustrated on the Falkland archipelago flora. Sheep deteriorate and eventually destroy the pasture-lands over which they graze, and this fact is very apparent when one follows up a vast flock while feeding. They pull up whenever possible the tufts of the finer grasses by the roots, and orchids and Tussac grass are eaten down to the ground, in the case of the former plants the bulbous roots being even devoured, so that it is useless to look for plants in the sheep-paddocks. Sheep also nibble the young shoots of *Chiliotrichum amelloideum* and *Veronica elliptica,* destroying in places whole valleys of the former to which they have access. The delicate agarics are nearly all to be found in the shelter of the former shrub in deep valleys rich with humus.

"Most of the lichens were collected in the uplands near Roy Cove at a height of about 150–300 ft., where foliaceous and fruticolous species abound. One of the most interesting is *Parmelia lugubris,* which is found in great abundance where *Empetrum* covers the hills. When moist it is a very delicate green and black underneath with brown tips, when dry the green pales and it is practically black and white. Owing to its hollow thallus inflated with air, detached pieces are carried for miles by the wind, and it is thus plentiful all over the uplands. Cup-lichens (*Cladoniæ*) are especially common on burnt or half-burnt bogs. The foliaceous forms (species of *Parmelia* and *Sticta*) are often much injured by sheep, so that great difficulty is experienced in obtaining perfect specimens. Even on exposed summits, such as Rame Head and Mount Adam, a very luxuriant lichen vegetation exists, the beautiful *Neuropogon melaxanthum* being particularly fine and forming a veritable miniature forest.

"The littoral of the islands is fringed with *Empetrum rubrum*, the 'heather' of these climes, but this never extends many miles inland. A belt of maritime lichens, of which *Ramalina terebrata* is one of the largest and most conspicuous, is noticeable on the shore, and the beautiful orange-red alga (*Trentepohlia polycarpa*) is also espcially common on maritime rocks.

"The coarse white grass (*Arundo pilosa*), which gives to the pasture-lands in sunshine a corn-golden tone, covers vast areas, and 'Fachina' (*Chiliotrichum amelloideum*), on which a new Uredine was found, fills the valleys, the sweet-scented *Veronica elliptica* occurring only on the littoral of the Western Island. Immense tracts of ground are rendered quite useless by the two ferns *Lomaria alpina* (=*Blechnum Penna-marina*, Kuhn) and *L. magellanica* (=*Blechnum tabulare*, Kuhn), which no animal will devour, but their uselessness is in some measure compensated for by their varied hues, which add to the beauty of the undulating land. That most striking plant *Bolax glebaria*, which drew forth from Penrose some quaint and original remarks in his account of the British Settlement on Saunders Island in 1775, flourishes everywhere. On the dead stems of this plant, as also on the *Veronica* and *Lomaria*, delicate epiphytic Agarics were found (*Pleurotus* spp.?), but these unfortunately proved indeterminable.

"The streams of stones or 'stone runs' are one of the best-known features of the whole archipelago. They are more common on the eastern island than elsewhere, and are interesting botanically on account of their islets of vegetation. Saxicolous lichens are plentiful on the boulders composing the 'runs.' Sand-hills, like the dunes in the eastern counties of England, occur in many places, and in some instances they are covered with a luxuriant growth of *Senecio candicans* and *Chiliotrichum amelloideum*. It was presumably on this type of ground that the curious fungus *Bulgaria arenaria*, Lév., reported by Gaudichaud, but not since re-discovered, was gathered.

"With regard to the marine algæ, enormous quantities of 'Kelp' are washed ashore, and after severe gales banks may at times be seen 6 feet high and 10–15 yards wide, stretching for 100 yards or more along the shore. This represents many tons of *Durvillea*, *Macrocystis*, and *Lessonia* torn up and hurled ashore from deep water. One fact particularly attracted my attention during a big on-shore gale, and I noted it also on several subsequent occasions. When the 'Kelp' is being torn up and the fronds and stems are being broken by the fury of the elements, the mucilaginous substance exuded from these broken seaweeds is so great that it has almost the effect of oil in smoothing the crests of the waves. This is at times so markedly the case that the rollers lose much of their danger.

"Our chief collecting-grounds for algæ were West Point Island, Roy Cove, and Shallow Bay, but in addition to these we were able to wander many miles along the sheltered creeks and fiords on most parts of the West Falklands.

"*West Point Island.*—On this island, 35 miles from our headquarters, there is only one real shore-collecting area, namely, along the strand below the settlement. Elsewhere furious seas sweep the shores, and collecting is onfined to 'beach combing,' *i.e.* turning over 'Kelp' thrown on the beach after gales. In the cove below the settlement some excellent collecting was done, and it is from this spot that the majority of the sea-weeds labelled 'West Point Island' were obtained. The beach within tidal limits is composed of ground-up quartzite with rounded boulders scattered here and there. Along the northern edge of this cove are many rock-pools teeming with various sea-weeds. Beyond this is the ever-present 'Kelp,' *Macrocystis*, which fringes the shores.

"*Hope Harbour.*—On the mainland opposite West Point Island is Hope Harbour, a large and almost land-locked natural indentation of the coast. Along its shores on the northern boundary rock-pools abound, while the southern shore is sandy with rocks interspersed. At the head of the harbour is a fresh-water stream which is frequented at spring tides during summer and autumn by large mullet. The majority of the rocks are small enough to be turned over with the hand, and littoral life is plentiful owing to the sheltered position.

"*Roy Cove.*—Another natural indentation of the coast, and placed on the northern shore of King George's Bay. It was in this place that we spent nearly a year, and were thus able to dredge and make large collections. The creek is about a mile and a half in length, and as the rocky sides are mostly steep, with a tidal rise and fall of ten feet at springs, it forms an ideal place for zoological and botanical collecting.

"For convenience of description the creek is easily divided into three parts—an outer, a middle, and an inner basin,—each part being connected with the other by a narrow strip of water. From the inner basin this estuary divides into two parts, each being derived from a stream of fresh water which flows down into it from the valleys. The shores within tidal limits are rocky, being formed of quartzite and being cut up into rocky pools and sheets of fantastic shapes, especially above high-water mark. During the winter, if the weather is at all severe, ice forms in the creek; and within living memory a solid sheet has been observed extending from the mouth to the extreme ends. Although waves break across the entrance, they never extend beyond the first basin, and it is in this region and especially in the second expansion that the fauna and flora are most luxuriant. Above this point the fresh water seriously affects the littoral fauna and flora, although in the deeper water the dredge continues to capture interesting forms.

"*Shallow Bay.*—This bay, where we lived for six months, is shallow, very inaccessible, and absolutely land-locked. It is about 30 miles north-east as the crow flies from Roy Cove, and really forms a continuation of Port Egmont, being part of an inner passage to Tamar Harbour, the first port on the north coast of the West Falklands. The whole of Shallow Bay is

practically a vast submerged bed of *Mytilus magellanicus*, in which a small quantity of *M. edulis* is mixed ; seaweeds, red and brown, are fairly common on the rocks and also in the tidal pools.

"*Port Egmont.*—A large natural harbour open to the north with good anchorage, and the original British settlement of the island. Unfortunately no dredging could be done here, but various seaweeds were gathered along the southern shore between tide-marks. Reef-channel is a very dangerous winding passage leading from the south side into Byron Sound. The tide here runs at 8–10 miles an hour, and seaweeds abound on the rocks and also in the pools throughout its whole length. Rocks, large and small, are scattered along the shores, and these, while being large enough to withstand the rushing waters, are easily turned over by the hand ; hence the locality is an ideal collecting-ground for the botanist and zooologist."

3. Acknowledgments.

In working out the present material it is a pleasure to acknowledge the help received from botanists of the British Museum, from Miss A. Lorrain Smith for assistance with several lichens, and from Mr. A. Gepp in connection with Antarctic algæ, with which he and Mrs. Gepp have been so much associated. My thanks are also due to Dr. O. V. Darbishire and to Mr. W. B. Grove for help with Antarctic lichens and Uredineæ respectively, and also to Madame Weber-van Bosse for kindly lending some type-specimens of algæ from Kützing's herbarium now in her possession.

Finally, the valuable work of Madame Paul Lemoine, D.Sc., must be gratefully acknowledged. Few marine algæ have been so much confused and neglected as the Lithothamniæ and the Melobesiæ, and the value of expert knowledge in this group is specially necessary. Madame Lemoine had lately been engaged in a revision of all the Antarctic species, and she kindly consented to examine Mrs. Vallentin's specimens and compare them with authentic material. Her report, which includes interesting notes, is published as received, at the end of the section on algæ.

I. THE CRYPTOGAMIC FLORA.

1. Historical Résumé of Previous Work.

The following sketch deals with all the previous collections of cellular cryptogams made in the Falkland Islands, and, in addition, the results of the most important expeditions to Fuegia and the adjoining mainland are alluded to.

The early botanical exploration of these regions was carried out almost exclusively by the French, the flowering plants naturally receiving foremost attention. The first reference to the cryptogamic vegetation of the Falkland Islands is by Pernety who accompanied Bougainville, the famous French

soldier and traveller, in his expedition to found in 1764 a French colony in those islands. In Pernety's 'History of the Voyage' (1771)* a full account of the new colony is given, together with a good map, views, and notes on natural history. He refers more than once to the vast beds of "sea-grass," *Macrocystis.* A few years later the French botanist Commerson (see Oliver, '09) accompanied Bougainville in his voyage round the world, and to him is due our earliest knowledge of the cellular cryptogams of the Cape Horn region. He collected in 1767 several lichens, an alga (*Trentepohlia*), and a fungus (*Cyttaria*) in the Magellan Straits, and his plants are now in the Paris Museum, though a few duplicates found their way both to the British Museum and Kew. Considerable space is devoted to this region in Bougainville's own narrative (1771), which was translated into English the same year. An account by Penrose (1775) of his visit to the Falklands in 1772 is also of interest.

Unsettled times followed in the political history of the islands, and for close on fifty years little additional botanical information was forthcoming. During the 'Uranie' and 'Physicienne' Expedition (1817–20), commanded by Freycinet, Gaudichaud made large collections in the Falklands, and, though owing to the wreck of the 'Uranie' in Berkeley Sound most of his valuable finds were lost, he was able, in his report on the flora of the islands, to list 21 algæ, 19 lichens, and 2 fungi (Gaudichaud, '25, pp. 96–97).

During the voyage of the 'Coquille' under Duperrey (1822–25) considerable attention was paid by d'Urville to Falkland Island plants. In the "Flore des Malouines," which he published in the 'Mémoires de la Société Linnéenne de Paris' (1826), he devotes several paragraphs to observations on large seaweeds, and his list of the flora contains 32 algæ, 34 lichens, and 2 fungi. These include Gaudichaud's records (slightly modified) as well as the material collected by Lesson and himself which had been determined by Bory de Saint Vincent. The same list appears in the full account of the 'Uranie' and 'Physicienne' Expedition (Freycinet, 'Voyage autour du Monde,' 1826), as Gaudichaud was able in the chapter on the Falkland Islands flora (pp. 123–143) to include d'Urville's plants which had been published in the Mémoires of the Linnean Society of Paris. In Duperry's account of the 'Coquille' Expedition, the volume on the cryptogams was prepared by Bory, who deals at length with d'Urville's collections, but does not distinguish the Falkland Island flora as such.

In Weddell's account of his remarkable voyage to the Antarctic ('25), considerable information is given as to the Falklands, including a map of Berkeley Sound, in which the "islands" of *Macrocystis* are indicated.

The 'Astrolabe' and 'Zelée' Expedition (1837–40), commanded by d'Urville, further explored the Magellan region and collected many plants

* See Bibliography, p. 226, arranged under four headings.

including algæ and lichens, but the Falkland group was not visited (see Montagne, '42–5).

In a revision by Crié of the plants obtained by these earlier collectors a few epiphytic fungi are recorded ('78).

The 'Beagle' visited the Falklands in 1833 and 1834. The collections made by Captain King, and later by Darwin, included several lichens and algæ. These were dealt with by Hooker in the great work mentioned in the following paragraph, and the plants are mostly at Kew. An excellent account and historical sketch of our islands is given by Fitzroy in his narrative of the second 'Beagle' voyage (see King, '39).

With 1842 we come to the visit of the 'Erebus' and 'Terror.' Sir Joseph Hooker writes in the introduction to the 'Flora Antarctica':—"A prolonged stay in the Falkland Islands, though the season was winter (April to the beginning of September), afforded opportunity for thoroughly investigating the flora of that interesting and now highly important group, which, though it had been partially examined by Admiral d'Urville and previously by the officers of that unfortunate ship the 'Uranie' under command of Captain Freycinet, still afforded considerable novelty" (Part I., p. ix). And later he states:—"During which year (1842) almost all the previously known species were gathered, with numerous others, specially Cryptogamia, by myself and Dr. Lyall, whose beautiful collections of the interesting algæ of this group of itself forms an important addition to antarctic Botany" (p. 215). He also acknowledged algal accessions to his herbarium from Captain Sulivan, Mr. Wright, and Mr. Chartres, surgeon H.M.S. 'Philomel.'

The results of Hooker's explorations are published in full and summarised in the 'Flora Antarctica,' Part II., though this was preceded by several preliminary papers. With regard to cellular plants, the algæ are dealt with by Hooker and Harvey, the lichens by Hooker, and fungi by Berkeley. The pages of that work testify to the care bestowed upon the collections, and the thoroughness of the collecting is proved by the comparatively few additions, except in the case of small and microscopic species, since made to the flora. With reference to the changes which it has been necessary to make in nomenclature, most of these are due to different conceptions which obtain to-day with regard to genera. A more exact knowledge of species also has rendered imperative a critical revision of all the older extra-European records, but in the case of the algæ, at all events, changes due to this cause are not numerous in the Magellan region.

Between Hooker's time and the French Expedition to Cape Horn in 1882, little additional knowledge of the cryptogamic botany of our area was obtained. The Falkland Islands material distributed in Hohenacker's well-known exsiccatæ was obtained by Lechler, who visited these islands as well as the Magellan Straits in 1850 and 1852. Both algæ and lichens are represented. The British Museum herbarium possesses a collection of marine

algæ obtained by Captain Abbott in 1859 mostly from Port Stanley. This officer, Mr. Vallentin informs me, was stationed for some years at Stanley in charge of a detachment of troops. He spent much time in the study of the fauna of the East Falklands, and was the author of several papers on the birds of the islands. His algal collection was named by Agardh, but no list was published. The 'Nassau' Hydrographic Expedition (1866–69) touched at the Falklands in 1867, and Cunningham, naturalist to the expedition, refers in his narrative to the flowering plants of the islands and also to "the gigantic seaweed *Lessonia fuscescens*" ('71, p. 156). He collected a few algæ and lichens, which are now at Kew, the latter being dealt with in a paper by Crombie ('76). Naumann, who accompanied the German 'Gazelle' Expedition (1874–76), also collected various cryptogams in the Magellan region, the determinations of which appear in the botanical reports of the voyage (Engler, '89). The Falkland Islands were, however, not visited.

The account of the 'Challenger's' stay at the Falklands will be found in the 'Narrative' (vol. i. part 2, pp. 883–901). The Kew herbarium shows that a few lichens and fungi were collected, though not apparently reported on.

Hariot's memoirs on the botanical collections of the French Mission to Cape Horn (1882–83), though not immediately concerned with the islands under notice, form a most useful and important contribution to our knowledge of the flora of the whole Cape Horn region. M. Hariot, who accompanied the expedition, collected plants of all kinds, and himself published the account of the algæ and fungi ('89), giving at the same time a chronological summary of previous work for both these groups and also for the lichens. He incorporated in his own papers previous records, and includes the Falkland Islands in his distributional notes. The section on lichens by Müller Arg. ('89) is, on the other hand, confined to the material collected by the expedition.

About this date several important cryptogamic papers appeared, which, though not dealing with the Falkland Islands themselves, should be consulted in any work connected with this geographical region. Of these, the lists by Nylander ('88) and by Müller Arg. ('89) of the Lichens of the Magellan neighbourhood should be mentioned, also Spegazzini's lengthy paper on the Fungi of Fuegia ('87), and Reinsch's report ('90) on the marine Algæ of South Georgia. Malme's account of the Stictaceæ of Patagonia ('99) is likewise worthy of attention. A paper by Svedelius ('00) on the Chlorophyceæ of the Magellan Straits should also be noted, especially as his records are not included in Gain's table of South-American algæ ('12, p. 117).

Mr. Rupert Vallentin turned his attention to the Falkland Islands algæ in 1898, when he sent home a small collection from Port Stanley. This was named by Mrs. Gepp, and is to be found in the British Museum herbarium.

A few lichens were received at Kew a short time previously to this from Mr. A. Linney, gardener at Government House, Port Stanley, and also from Miss Firmin from the Western Islands. Mr. A. W. Hill touched at the Falklands on his return voyage from the West Coast of South America in 1902, and amongst other plants collected were a few algæ and two specimens of Uredineæ.

Of the numerous recent Antarctic expeditions, the collections of which have been worked out, only one is directly concerned with the Falklands, namely the Swedish Polar Expedition of 1901–3. Magellan plants were, however, collected by the first Swedish Expedition (1895–97) and also by the Belgian Expedition ('Belgica,' 1895–97), whilst the South Orkneys and Gough Island were explored by the Scottish National Antarctic Expedition ('Scotia,' 1902–4). Both the French expeditions, the 'Française' (1903–5) and the 'Pourquoi Pas' (1908–10), confined their collecting almost entirely to the Graham Land region, and the German South Polar Expedition of 1901–3 ('Gauss') visited Kaiser Wilhelm's Land; whilst the three English expeditions, the 'Southern Cross' (1895–1900), the 'Discovery' (1901–4), and the 'Nimrod' (1907–9), all proceeded *viâ* New Zealand or Tasmania to Victoria Land. It should, however, be mentioned that as a result of the 'Pourquoi Pas' collections two valuable memoirs of wide scope have appeared. M. Gain, naturalist to the expedition, not only gives an account ('12) of his own collections of marine algæ, but also valuable summaries of previous work in the Antarctic regions; while Dr. M. Lemoine, who worked out the Lithothamnia, has provided what is practically a critical monograph ('13) of all the antarctic Melobesieæ.

In the results of the second Swedish Expedition (1901–3), on the other hand, the Falkland Islands figure largely. This is greatly owing to the fact that much of the material from other localities was lost with the ill-fated 'Antarctic.' Dr. C. Skottsberg with his indefatigable zeal had amassed large quantities of plants from South Georgia, Falkland Islands, Fuegia, and Graham Land, including, he states, "überraschende Dinge aus dem eisigen Meere." Three papers dealing with cellular cryptogams have been published—namely, Skottsberg's report on the Phæophyceæ ('07), which includes besides the description of several novelties the results of his morphological and anatomical investigations, Darbishire's account of the lichens ('12), and Carlson's paper on the fresh-water algæ ('12). Darbishire's paper gives summaries and tables of antarctic and subantarctic lichens, and it has been of great service in working out Mrs. Vallentin's collections. In Carlson's 'Süsswasseralgen aus der Antarktis' we have the first and only account for our archipelago of the algæ in question. From it the Falkland Island records have been picked out for the present paper, and they are given in a special list after the marine algæ.

Mrs. Vallentin's collections were made subsequently to the Swedish Expedition, but, unlike that and all previous explorations, the collecting was

carried out entirely in the wild and lesser-known West Falklands. The foliaceous lichens of this region are particularly fine and abundant. As will be shown later, Mrs. Vallentin's collections provided not only many additional records and several novelties, but also give for the first time a clear idea of the fungus flora of the islands. Since her plants were worked out, a small set of marine algæ providing several items of interest and a few additional names has been examined. This collection was made by Miss F. J. Hennis in West Point Island in 1911, and was sent to Kew on loan.

2. Floristic Notes.

The cryptogamic flora of the Falklands is from a geographical standpoint the same as that of Fuegia, the difference of its character—shown in the absence of many species—being due to habitat-conditions, such as the lack of mountains, the absence of woodland, and the consequent severe exposure to wind. Amongst the Phanerogams there are a number of endemic species, 15 are listed by Skottsberg, but this does not appear to be the case with the light-spored cryptogams. To the complete lack of trees must be attributed the absence of many lichens and also the wood-loving fungi, though with regard to the former, owing probably to many forms being adapted to bleak conditions, the list includes a large number of foliaceous and fruticulose species, and some of these occur in profusion. The marine algæ (though behind Fuegia in point of numbers) are in agreement with the view expressed above. The conditions necessary for their growth are practically the same in the two areas; hence, though each possesses species not so far found in the other, the flora is essentially one. For these reasons there is no need to draw comparisons between the two areas; further particulars can be obtained by consulting the lists in the present paper and the various Fuegian and Magellan enumerations which have been published.

A few remarks on the Falkland flora as represented by each group of the Thallophyta are given below, the total number of species listed for the respective groups being as under:—

Marine algæ	148
Fresh-water algæ . .	53
Lichens	75
Fungi	33

(a) *Marine Algæ*.—The proportions of the various groups are as follows:—

Cyanophyceæ . . .	4
Chlorophyceæ . . .	25
Phæophyceæ	41
Florideæ	78
	148

Of these, 19 are additions to the previous list and 3—*Endoderma maculans, Pteridium Bertrandii, Epilithon Vallentinæ*—are new species. On the other hand, it has been possible to remove from the older lists 12 names as erroneous records or synonyms of other species.

In the Chlorophyceæ the presence of 4 members of the Siphoniæ (2 species each of *Codium* and *Bryopsis*) is noteworthy in a flora having a well-marked subantarctic facies. In the Browns the Dictyotaceæ are, as might be expected, entirely absent. Amongst the larger species the dominant algæ are *Macrocystis* and species of *Durvillea, Lessonia,* and *Desmarestia,* these taking the place of the Fucaceæ and Laminariaceæ of the northern seas. Some notes on the Kelps by Mrs. Vallentin will be found on p. 141. The Florideæ exhibit special luxuriance. Not only do we find the huge fronds of *Gigartina radula* and *Iridæa laminarioides,* but amongst the delicate *Nitophylla* and *Delesseriæ* many large and very beautiful species occur. The most abundant red algæ, in addition to the two above mentioned, are *Callophyllis fastigiata, C. variegata, Plocamium secundatum, Glossopteris Lyallii, Ptilota magellanica, Polysiphonia* spp., *Plumaria Harveyi, Ballia callitricha,* and the ubiquitous *Ceramium rubrum. Lithothamnia* are frequent, but members of the Corallinæ-articulatæ, though represented by several species, are scarce.

(b) *Fresh-water Algæ.*—According to Carlson's list, the different groups figure in the following manner :—

Myxophyceæ	6
Bacillariales	36
Heterokontæ	1
Chlorophyceæ	10
	53

In the case of the Diatoms the above figures include also brackish and marine species, but in the Myxophyceæ and Chlorophyceæ the few marine species dealt with by Carlson are not taken into account in the above table.

(c) *Lichens.*—No new species were obtained, but 6 names have been added to the existing list.

It would appear from Mrs. Vallentin's collection that the large foliaceous and fructiculose species are more plentiful in the West Falklands than in the East. *Parmelia lugubris,* for instance, is extraordinarily abundant ; and two very fine species of *Sticta* (*S. endochrysa* and *S. Freycinetii*), found in several localities by Mrs. Vallentin, were not noted at all by Skottsberg. The same is the case with several Cladonias. In these and in other instances many of the species were gathered in the eastern islands by Hooker and the early collectors ; and the fact that they were not found by Skottsberg

perhaps shows that since those days the larger lichens have been reduced in numbers, though in the western islands they still flourish.

(d) *Fungi.*—Of the 36 species now known from the Falklands, 22 or almost two-thirds are additions to the Falkland Island list, and of these 6 are described for the first time. Out of the total, about 15 are conspicuous macroscopic species, the remainder are small parasites or epiphytes. Being a treeless archipelago, the woodland species of Fuegia are absent.

The coloured drawings of fungi by Mrs. Vallentin supply us with a vivid picture of the terrestrial fungus flora. In the grassy valleys between the mountain-slopes there are, at certain seasons, a considerable number of small Agarics. The genera are clearly those of the pastures and moorlands of Northern Europe, but the question of species is very much more difficult. Even in a country such as England, where the possibilities are known, it is no easy matter to name members of Agaricaceæ from drawings and spirit-material. The characters are based on such unsuspected features that the artist usually needs the specialist's help to be enabled to portray them. It is not surprising, therefore, that some of the fungi depicted by Mrs. Vallentin have had to remain unnamed. On the other hand, several interesting pasture species have been recognised, including *Agaricus campestris*, *Lepiota granulosa*, *Mycena polygramma*, several Puffballs, and *Cordyceps militaris*; the pyrophilous Discomycete *Plicaria leiocarpa* may also be mentioned. In dealing with extra-European collections it has in the past often been the custom, and sometimes with good reason, to describe unrecognised species as new. But the more Mrs. Vallentin's specimens were studied, the more the resemblance to our British forms was apparent, though at the same time there was great difficulty in stating their specific identity. See also remarks on p. 157.

3. Phytogeographical Considerations.

A few words may first be said on the phytogeographical divisions, and on the data available for comparison. Although the terms "antarctic" and "subantarctic" have been used by botanists in various ways, most writers are agreed in including the Falkland Islands in the antarctic region in its widest sense. In the following remarks I have followed Gain ('12), who, for botanical purposes, places his antarctic boundary at 60° S., instead of the geographical 67°, and defines the subantarctic region as the area below that latitude in which the action of ice is felt. According to this method, Graham Land, the South Orkneys, and South Shetlands find a place, together with the lands within the actual polar circle, in the Antarctic Region; whilst Fuegia, the Falklands, South Georgia, Bouvet, Crozets, Kerguelen, Marion, Possession, Campbell, Auckland, and Macquarie Islands fall into the Subantarctic Region. It will be noted that the northern boundary of this

subantarctic zone is irregular and does not follow a parallel of latitude. In longitude 60° E. it occurs at about 45° S.; in South America, where the Straits of Magellan form the boundary-line, it is 53° S. (See map in Gain, '12, p. 106.) In spite of this, however, Fuegia and the Falklands are less affected by ice than the other localities.

Madame Lemoine in her paper on the 'Pourquoi Pas' Melobesieæ ('13) adopts the same northern boundary, but does not distinguish a subantarctic division, the whole area within the limit of floating ice being termed by her the "Antarctic Region." This she divides by longitude, and distinguishes three regions corresponding to the continents or oceans with which the islands are more or less connected, namely, South American (or South Atlantic), South Indian, and South Australian. These divisions are convenient both from a geographical and also from a botanical standpoint, and they will be adopted in the present survey of the cryptogamic flora, though we will maintain at the same time the antarctic and subantarctic regions as defined above.

In considering the relationships of the cryptogamic flora of our islands, it is the marine algæ which will come most prominently before us. Compared with the other groups, these have been both more largely collected and more carefully studied. The lichens follow, and in the case of Fuegia and Kerguelen are well known. For the fungi, on the other hand, few data are available. On wind-swept islands fleshy species are scarce and few collectors have searched for microscopic forms, which, even were they known, are not yet of much value for comparative purposes.

With regard to the three divisions of the subantarctic region, the Southern American is easily first, and, except for microscopic species, we have now a tolerably thorough knowledge of all cryptogams from this area. Lengthy lists of Magellan plants have been published, though in several genera considerable revision is necessary. The same cannot be said of the South Indian or South Australian divisions; indeed, the need of further material from these areas, and the necessity of a thorough revision of the older records, has been very evident during the working out of the present collections. Of Kerguelen, it is true, our knowledge has increased of late, and Laing's paper ('09) has helped with regard to the algæ of the New Zealand subantarctic islands, but very many plants doubtless remain to be detected and numerous obscure points need to be cleared up.

The following remarks therefore deal only with the broad outlines, and not exact statistics. So far as the Falkland Islands themselves are concerned, the lists should be fairly correct. In the case of the marine algæ an effort was made, by means of the examination of original material and of type-specimens, to bring about this end, and to a lesser extent the same applies to the lichens and fungi.

A. Marine Algæ.—In comparing subantarctic floras we find that not only have these been more thoroughly investigated, but, at the present at all events, they offer greater scope. Many of the large and showy Florideæ are restricted in their distribution, and hence a greater variety is found in the different parts of the whole region (*cf.* Lichens, p. 156). This may be partly owing to the dispersal of spores being due to ocean currents, the influence of these in bringing about a wide distribution being less effective than wind. Yet this alone cannot be responsible, as we find that the three main groups of algæ differ amongst themselves in distributional range. This is shown in the following paragraph, where an attempt is made to give a general idea of the geographical components of the flora.

(*a*) *Analysis of Flora.*—As a general rule, the Green Algæ, if the Siphoneæ be omitted, show a larger proportion of cosmopolitan plants than either the Reds or Browns. Species of *Enteromorpha, Ulva, Cladophora, Rhizoclonium, Chætomorpha* very similar to each other occur all over the world, though they are more abundant in temperate regions. In the Falkland Islands nearly half the species have a sufficiently wide range to be regarded as practically cosmopolitan. Of the remainder, the majority, though these include several unsatisfactory species of *Cladophora*, are only known from the subantarctic American region. The most interesting plants are the members of the Siphoniæ, namely, *Bryopsis Rosæ* apparently endemic to subantarctic America, the widely distributed *Codium difforme,* and *C. mucronatum*, whose curious distribution is mentioned later (p. 165). *Prasiola crispa,* found in the colder and temperate regions of both the North and South hemispheres, is also worthy of note.

In the Brown Algæ we have out of 41 species only 3 which are cosmopolitan (*Pylaiella litoralis, Ectocarpus siliculosus*, and *Sphacelaria furcigera*), and 3 which flourish in both north and south temperate regions (*Phyllitis fascia, Scytosiphon lomentarius*, and *Desmarestia ligulata*) ; though to these should be added the doubtful record of *Punctaria plantaginea* and another possible cosmopolitan in the presence of *Colpomenia* sp. The remainder, with the exception of *Macrocystis* (and the somewhat doubtful *Chordaria*), are confined to the southern hemisphere, and a large proportion do not occur north of the subantarctic regions. A few extend to South Australia and New Zealand, and others, favoured doubtless by the Humboldt current, occur on the west coast of South America. The distribution of *Macrocystis,* which is shared to a large extent by *Iridæa cordata* and *Gigartina radula,* is interesting and instructive.

The Florideæ on analysis come out in very similar proportions to the Browns. About half out of 80 odd species are confined to the subantarctic or antarctic regions ; others extend as far north as South Australia and New Zealand, or advance up the Chilean coast; whilst 10 or 12 are cosmopolitan or at least occur very widely in temperate regions. The cosmopolitan species belong to the genera *Porphyra, Ceramium,* and *Corallina. Gigartina radula*

and *Iridæa cordata* are abundant in the North Pacific, and the latter occurs also at the Cape.

It has been shown above (p. 148) that there is no need to examine the differences in the algal flora of the Falkland Islands and Fuegia, but a brief comparison with that of Kerguelen, the subantarctic islands of New Zealand, and also with the true Antarctic, though not throwing much light on the origin of these floras, brings out a few interesting points.

(*b*) *Comparison with Kerguelen* *.—This is the only representative of the South Indian division of the subantarctic, the flora of which has been at all satisfactorily investigated. The climate is decidedly colder than that of Magellan, as may be seen by comparing the mean monthly temperatures obtained by the 'Gauss' and Swedish Antarctic Expeditions. For this reason, as well as from its isolated position, the flora is, as might be expected, much poorer in species. As Hooker pointed out, it closely resembles the Fuegian and has no affinity with that of South Africa—it is, in fact, entirely subantarctic, though lacking a large number of species which are found in the Magellan region. From the presence of endemic phanerogams, 6 out of a total of 21, Werth ('11, pp. 361–5) does not favour Hooker's view that the flora immigrated from the west, and hence a more accurate knowledge of the marine algæ would be of great interest as bearing on this point. Kerguelen has several algæ not found in the Magellan area; 14 are listed by Gain ('12, pp. 128–132), but only six of these have any claim at present to be regarded as endemic, even if we include, as we may with fairness, two from Heard Island and Marion Island. The 14 species referred to are:—

Desmarestia chordalis.	*Delisea pulchra.*
(*Callophyllis tenera.*)	*Ptilota Eatoni.*
(*Callymenia dentata.*)	(*Rhodochorton Rothii.*)
Epymenia variolosa.	*Lithothamnium Kerguelenum.*
Plocamium Hookeri.	(*Scytothalia obscura*) (Heard Island).
(*Nitophyllum crispatum.*)	*Callophyllis elongata* (Heard Island).
Nitophyllum fuscorubrum.	*Cladhymenia pellucida* (Marion Island).

Of these, the 5 included between brackets may, for reasons explained in the footnote †, be disregarded. Of the remainder, *Desmarestia chordalis*, *Epymenia*

* Throughout this paper only large or fairly conspicuous species are used for comparative purposes, small species are too easily overlooked to be at present of value.

† *Callophyllis tenera.*—It is possible that *C. tenera* may be a synonym of *C. fastigiata*, but the 'Challenger' examples, on which the record was based, may certainly be taken as forms of that species, which is also common in the Falklands.

Callymenia dentata.—Record certainly incorrect, most of the specimens are *Rhodymenia palmata.*

Nitophyllum crispatum.—A very doubtful record. Other species might easily be mistaken for this, which at present is only known from Auckland and Campbell Islands.

Rhodochorton Rothii.—The Kew specimens are epiphytic on *Ahnfeltia*, and certainly distinct from this northern species. Possibly new and undescribed.

Scytothalia obscura.—A very doubtful plant, based on a single and young specimen.

variolosa, Nitophyllum fuscorubrum (see note, p. 201), and *Lithothamnium kerguelenum* (see Lemoine, '13, p. 8), are at present only known from Kerguelen, and the last two on the list only from the islands mentioned. *Plocamium Hookeri* is very frequent on Kerguelen, and has been found elsewhere in South Georgia and at Macquarie Island. *Ptilota Eatoni*, also a common Kerguelen species, has lately been recorded from Graham Land. The most interesting species is undoubtedly *Delisea pulchra*, which gives another link with Australia. Its headquarters are in New South Wales and New Zealand, though it has not been collected from the subantarctic islands of that continent. It was collected at Kerguelen by Hooker and also by the 'Challenger' Expedition. When better known it is possible that the plant may prove to be a distinct subantarctic species, but, in any case, the affinities of the genus are Australian rather than South American.

The number of Falkland species absent from Kerguelen is, on the other hand, considerable, as will be seen from the following list:—

Codium mucronatum.
Bryopsis Rosæ.
Corycus prolifer.
Phyllitis fascia.
Stictyosiphon Decaisnii.
Gelidium crinale.
Catenella Opuntia.
Acanthococcus spinuliger.
Schizoneura Davisii (see p. 185).
Chondria sp.
Lophurella comosa.
Bostrychia Hookeri.
Bornetia antarctica.
Callithamnion Montagnei.
Plumaria Harveyi.
Ballia scoparia.
Antithamnion flaccidum.
Hildenbrandtia Cannelieri.
Corallina officinalis.
Corallina pilulifera.
Amphiroa spp.

(*c*) *Comparison with Australian Region.*—An immense advance in our knowledge of the fauna and flora of this region of the subantarctic may be expected from the results of the collections made at the station established by the Australian Antarctic Expedition on Macquarie Island. Meanwhile, we have the two valuable volumes, edited by Chilton, entitled 'The Subantarctic Islands of New Zealand' ('09), which give summaries of the flora so far as at present known. The report by Laing on the marine algæ ('09) is the most complete of any on the cellular cryptogams. On examining his list one is struck immediately by the large number of species which belong to New Zealand and even Australia, and the small percentage of Fuegian or circumpolar forms. This is partly to be accounted for by the fact that most of the records are from the Aucklands group, and that from Campbell and Macquarie Islands (the only ones within the summer limit of icebergs) much fewer algæ have been collected *.

* It should, however, be stated that, according to the map provided by Chilton, Kerguelen also is outside the summer limit of icebergs.

But even if the Campbell Island list be analysed (Macquarie may be omitted, as not more than 2 or 3 algæ have been recorded), a number of very marked New Zealand types are present, and at a liberal estimate (though excluding cosmopolitans) only half the number of species can be regarded as circumpolar. As the list is admittedly very incomplete and also in need of revision, it is not worth while giving the full analysis, but it may be stated that, apart from *Durvillea antarctica*, *Adenocystis utricularis*, *Scytothamnus fasciculatus*, *Desmarestia Willii*, *Heterosiphonia Berkeleyi*, and *Ballia callitricha*, with *Macrocystis*, *Iridæa cordata*, and *Gigartina radula* of wider range, there are, excluding cosmopolitans, few species which can at present be stated to occur both in Fuegia and the subantarctic islands of New Zealand. From our present standpoint no region is in greater need of investigation than Macquarie, and the results of Sir Douglas Mawson's expedition are awaited with great interest.

(*d*) *Comparison with Antarctic Region.*—Amongst the many tables furnished by Gain ('12) is one showing the algal distribution in the antarctic and subantarctic regions. He lists 70 species for the former and distinguishes 3 elements—endemic, circumantarctic, and foreign,—by means of which he analyses the whole. Gain's table gives a full and clear idea of the distribution of the species in the different islands. The present paper, not being concerned with that area, throws little additional light on the subject except to show that of Gain's endemic species two may be removed from the list, namely, *Monostroma endiviæfolia* and *Callymenia antarctica*, as these are now recorded as occurring in the Falkland Islands.

On proceeding south from Cape Horn, a marked change comes over the flora. Of the 140 species listed for the Falklands, less than a quarter have been recorded for S. Shetlands, S. Orkneys, or Graham Land, whilst of the 65 species known from the latter areas not much more than half occur in the Magellan region. No doubt many algæ in the antarctic remain to be discovered, and not a few records require verification, but it is evident that the Graham Land flora is very distinct from that of Cape Horn, though there are many common species. How far the floras of Graham Land and Victoria Land correspond we are not yet in a position to say.

(*e*) *Summary.*—From the above comparisons, it will be seen that the algal flora of the Magellan region is a subantarctic one of a distinct South American type. Many of the species composing it appear to be confined to subantarctic America ; a large number are also found in the South Indian region of the subantarctic of which Kerguelen is typical, and a small proportion only are known from the subantarctic islands of New Zealand. In the same way we find that the algal flora of the latter islands has a distinct stamp, a very marked New Zealand element manifesting itself in both genera and species. The affinity of Kerguelen, which lies between, is American, but, in addition to the subantarctic American species, it possesses

M 2

some half-dozen large Florideæ not known from elsewhere and two species, absent in Fuegia, but found in New Zealand or its subantarctic islands.

The number of circumpolar species (excluding cosmopolitans) in the subantarctic region is, as far as we know at present, not great, but in higher latitudes, *i. e.*, in the Antarctic region proper, greater uniformity in the flora may be expected. Writing of the phanerogamic vegetation, Dr. W. B. Hemsley says in his report on insular floras for the 'Challenger' expedition, "the only admissible demarcation of the coldest floral region is a zonal one." This is most probably true also in the case of the algæ. But in the subantarctic, the floras of the eastern and western areas we have been considering are very distinct from each other, and are markedly related to those of New Zealand and South America respectively.

B. Fresh-water Algæ.—No attempt has been made to give a comparative survey of the subantarctic fresh-water algæ, as this can only be done by a competent specialist. In any case there is little data available, and all the older records require revision. The valuable papers by Fritsch ('12, '12 *a*, '12 *b*) and West and G. S. West ('11) deal with the Antarctic proper, but they are of interest in connection with Carlson's South Georgia and Falkland Islands lists ('13). Gain's tables ('12) should also be consulted.

C. Lichens.—With regard to lichens the widespread distribution of many of the larger species is well known, and this is very noticeable in the case of the Falkland Island flora. Out of the 75 species listed nearly half are so widely spread, most in hilly and alpine districts, as to be regarded as cosmopolitan. The fact that some are known from all continents, except Australia, probably implies nothing further than the fact that the mountainous regions of that continent have not yet been thoroughly searched. But in some genera this universal distribution does not obtain. Of the seven members of the Falkland Islands Sticteæ, for instance, five are confined to the southern hemisphere; in the genus *Placodium*, the new species lately described tend to show that some species are decidedly limited in their range, whilst in the small crustaceous species world-wide distribution appears to be the exception rather than the rule.

Darbishire has already given tables dealing with the distribution of the antarctic and subantarctic lichens, and his geographical observations ('12, pp. 61–66) are of interest in connection with the Falkland Islands lichen-flora. With regard to the subantarctic American region he compiled a list of 366 species, and these he analyses and compares with the New Zealand flora as follows:—

	Fruticulose.	Foliose.	Crustaceous.	Total.
Subantarctic American Species. . .	73	99	194	366
Found also in New Zealand	52 % (38)	35 % (35)	20 % (39)	31 % (112)

These figures show that the floras of the two regions have somewhat in common, and the affinity is largely amongst the fruticulose forms.

In a general way the wide distributional range of lichens must be attributed to the general dispersal of their spores by wind and to their hardy nature, their power of enduring cold and desiccation being well known to be remarkable (*cf.* Fungi, p. 158). Why it is that widespread and cosmopolitan species are much more numerous amongst fruticulose forms is not at all clear. Darbishire remarks with regard to this point:—"The fruticulose species are the oldest and probably least variable at present. The crustaceous species are more variable and have adapted themselves more to local conditions, thus giving rise to new species" ('12, p. 63). The human factor also is no doubt, as Darbishire allows, partly responsible, the minute size of many crustaceous plants making them easily overlooked and more difficult to identify from any book-descriptions.

The Kerguelen flora, which was not touched upon by Darbishire, shows on comparison two interesting features. In the first place, the scarcity of fruticulose and foliaceous plants is very noticeable. In Zahlbruckner's list, which is the most recent and, excluding Crombie's papers, the only one critical, this is exceedingly marked, only 1 *Cladonia*, 1 *Sticta*, 1 *Parmelia*, and 2 *Usneas* out of a total of 43 being recorded. Hooker and Taylor enumerated a few other large species, as did Crombie, but there is some doubt as to the earlier records (*vide* Crombie, '76, p. 180). The bleakness and barrenness of Kerguelen is well known, but with so many fructiculose and bulky foliaceous species in the Falklands (amongst others, 13 *Cladoniæ*, 7 *Stictæ*, 6 *Pameliæ*, 5 *Usneæ*) so small a number in Kerguelen is rather surprising.

The second feature is the floristic difference noticeable amongst the crustaceous species of the two areas. With the exception of the cosmopolitan *Rhizocarpon geographicum*, not one crustaceous species recorded by Zahlbruckner has been found in the Falklands, and very few are listed by Darbishire for Fuegia. The time has not yet come for drawing conclusions based on such small species, but it would certainly appear that the lichen-flora of Kerguelen has not much in common with subantarctic America. The permanently saturated soil of Kerguelen is probably unfavourable to the growth of foliose species, and the Falklands have the advantage of proximity to the mainland, by means of which the flora, through reproductive bodies brought over by the prevailing westerly winds, may be constantly renewed.

D. Fungi.—Little can be said with regard to this group in other parts of the subantarctic. Hennings ('06) has given a careful account of the Kerguelen material brought back by the 'Gauss,' and this may be compared with the Falkland Islands and Magellan lists. The lists, however, consist mostly of micro-species, and it is evident that our knowledge is very imperfect.

If compared with Europe we may safely say that the terrestrial fungus-flora of the Falklands must in a general way resemble that of our own islands. The genera are the same. Small species of *Tricholoma*, *Hygrophorus*, *Mycena*, and *Omphalia* are common, whilst amongst the pink and yellow spored sections species of *Entoloma*, *Galera*, and *Naucoria* are evidently frequent. The coprophilous (dung-loving) fungi are, as far as they have been investigated, identical with those of Europe; *Stropharia semiglobata*, *Coprinus radiatus*, and *Ciliaria stercorea* being common, and agreeing exactly in form and microscopic structure. The specific identity of the pasture-forms is exceedingly difficult, but, as stated above, several well-known British species are recognisable (see p. 150), and further work will doubtless reveal others. At the same time a definite South American type, if we may judge from the numerous new Agarics described by Spegazzini from Fuegia, is recognisable in the Magellan region. In the Falklands, however, this element, though obvious enough amongst the smaller and parasitic species, is not apparent in the pasture-species list at present available.

Contrasted with lichens, fungi may be said to be less hardy and less widely distributed. Many of the former can endure great extremes of temperature and also severe desiccation, and they must rank amongst the most widely distributed of all plants. Not a few lichens, moreover, occupying sea-level in cold and temperate countries are found in the mountainous regions of S. Europe, and at greater elevations on the Himalayas and mountains of Africa; and probably most of the species common to the Arctic and Antarctic occur, with a break at Panama, down the whole backbone of America. As far as is known, this is not the case with the fungi, the flora of the tropics being very different from that of Europe, though it should be noted that, as a rule, it is only the woody or coriaceous species that are forwarded or brought home for examination. In temperate S. America (Patagonia, the Argentine, and Paraguay) Spegazzini has collected and described many fleshy Agarics. Some of these he refers to already described species, but a large number he describes as new. The occurrence, therefore, of British species in the Falkland Islands tends to confirm the view that the light spores of the cellular cryptogams are universally distributed, and that the plants will flourish where conditions are suitable.

With regard to the parasitic and epiphytic fungi specialization is rather marked, several distinct rusts and other species occurring on various native plants in the Magellan area (see p. 224, and Spegazzini, '87, pp. 46–53). At the same time it is interesting to note the presence of the well-known *Puccinia Violæ* on *Viola maculata*, and *Cystopus candidus* on the endemic Crucifer *Arabis macloviana*.

From an ecological standpoint the fungus-floras of the subantarctic islands, when more thoroughly known, may well be compared with such treeless islands as Iceland and the Faroes in the North Atlantic, for both of which

Rostrupp has provided fairly lengthy lists ('03 and '03 *a*). Leege's papers on the flora of the East Frisian Islands, and Rea and Hawley's report ('12) for the Clare Island Survey are also of interest in this connection, the last-mentioned giving a list of important genera found on the mainland, but absent on Clare Island only three miles distant. As in the Falklands, the explanation is doubtless chiefly to be found in the severe exposure and the absence of trees.

II. SYSTEMATIC LIST OF MARINE ALGÆ.

CYANOPHYCEÆ.

Dermocarpa prasina, *Thur. et Born. Notes Algol.* ii. pp. 75–77, tab. 26.

E. Falklands; Berkeley Sound, *Hooker*; Port Stanley, *Hohenacker*. W. Falklands; Roy Cove, *Vallentin*.

Distrib. Cosmopolitan.

Hyella cæspitosa, *Born. et Flah. in Journ. de Bot.* ii. (1888) p. 162.

W. Falklands; in *Spirorbis*, Roy Cove, *Vallentin*.

Distrib. Probably cosmopolitan.

One of the shell-boring algæ, and not previously known from the Falklands.

Oscillaria nigro-viridis, *Gom. Oscill.* p. 237, tab. 6. fig. 20.

E. Falklands; Port Louis, *Skottsberg*.

Distrib. Probably cosmopolitan.

Calothrix æruginosa, *Thur. Ess.* p. 382; *Born. et Thur. Notes Algol.* ii. p. 157, pl. 37.

E. Falklands, *Bérard* (teste *Bornet*), *Hooker* (teste *Hariot*).

Distrib. Probably cosmopolitan.

CHLOROPHYCEÆ.

Chlorochytrium inclusum, *Kjellm. Algæ Arctic Sea*, p. 320.

W. Falklands: in *Iridæa cordata*, Rapid Point, *Vallentin*.

Distrib. N. Atlantic, N. Pacific, Fuegia.

With the exception of Hariot's record from Fuegia, this alga has not apparently been detected from elsewhere in the southern hemisphere.

Monostroma endiviæfolia, *A. & E. S. Gepp, in Journ. Bot.* xliii. (1905) p. 105, tab. 470. figs. 1–5; '*Scotia*' *Report*, iii. p. 73, pl. 1. figs. 1–5.

E. Falklands; Port William, *Hooker*. W. Falklands; West Point Island, *Hennis*; Roy Cove, in pools at half-tide, *Vallentin*.

Distrib. South Orkneys, Falkland Islands.

The present is the first record of *Monostroma* for the Falklands, and it is a genus apparently rare in subantarctic regions. *M. endiviæfolia*, though previously only known from the original locality, has probably in the past been mistaken for young plants of *Ulva*. A specimen of Hooker's inscribed "*U. rigida?*" exists at Kew, and this shows a distinct *Monostroma* structure and almost certainly belongs to the present species. Miss Hennis's specimen is larger and more laciniate than previous gatherings.

Ulva Lactuca, *Linn. Sp. Pl.* ii. p. 1163, *ex parte*.

Falkland Islands, general, all collectors.

Distrib. Cosmopolitan.

Each of the three varieties, or forms, *genuina*, Hauck, *rigida*, Le Jolis, and *latissima*, Ardiss., appear to be present, the last-named being, according to Hooker, abundant in land-locked lagoons.

Enteromorpha intestinalis, *Link, in Nees Hor. Phys. Berol.* 1820, p. 5.

Falkland Islands; probably general, *Hooker*, *Vallentin*.

Distrib. Cosmopolitan.

E. compressa, *Grev. Alg. Brit.* p. 180 (excl. var.).

Falkland Islands, most collectors, "very abundant," *Hooker*.

Distrib. Cosmopolitan.

Hooker included the following species, which is hardly distinct, under this name, hence *C. compressa*, though doubtless common, is perhaps not quite so abundant as he supposed.

E. Linza, *J. Ag. Till Alg. Syst.* vi. p. 134.

E. Falklands; "abundant," *Hooker*. W. Falklands; Shallow Bay, *Vallentin*; West Point Island, *Hennis*.

Distrib. Cosmopolitan.

Hooker's specimens have not been found in the Kew Herbarium. Mrs. Vallentin collected several plants, which are apparently referable to this species, but they approach very closely to the flattened tapering forms of *E. intestinalis*.

E. bulbosa, *Kütz. Sp. Alg.* p. 482.

E. Falklands; Berkeley Sound, *Hooker*. W. Falklands; Shallow Bay, *Vallentin*.

Distrib. Chile, Peru, Kerguelen, Cape, Tasmania.

Kützing detected this form amongst Hooker's Berkeley Sound specimens, and named it *E. Hookeri*; later it was shown to be a synonym of Suhr's *Solenia bulbosa*.

ENTEROMORPHA CLATHRATA, *J. Ag. Till Alg. Syst.* vi. p. 153, *sensu lat.*

W. Falklands ; Shallow Bay, *Vallentin.*

DISTRIB. Cosmopolitan.

It is curious that this generally distributed plant should not have been previously collected on the islands.

PRASIOLA CRISPA, *Ag. Sp. Alg.* p. 416. *Ulva crispa*, Lightf. ex Hook. f. et Harv. Fl. Ant. p. 498.

E. Falklands; Berkeley Sound, *Hooker.*

DISTRIB. Arctic and temperate regions of Europe, Asia, and Africa; Antarctic.

Fritsch ('12 *a*, p. 127, '12 *b*, p. 17) has dealt with the occurrence of this plant in antarctic regions, and he gives a useful account of the relationships of allied forms. The alga is a brackish and fresh-water species, and its growth is favoured by ammoniacal pollution. In Northern Europe it is often found in fine condition on the rocks below bird-colonies on sea-cliffs. In the Antarctic no data appear to have been given with regard to its habitat, but the presence of numerous small feathers amongst the "Scotia" specimens from the S. Orkneys is highly suggestive. Letts ('13) gives an account of experiments carried out with regard to its powers of absorbing ammonia (see Bot. Centralbl. Bd. cxxv. p. 298).

ENDODERMA MACULANS, *Cotton*, sp. nov. (Pl. **6**. figs. 1 & 2.)

Frondes endophyticæ maculas orbiculares 0·5–1 cm. diam. formantes, interdum confluentes. Thallus e filamentis articulatis ramosis deinde centro in stratum pseudoparenchymaticum concretis compositus. Filamenta radiantia plus minusve porrecta e cellulis 8–12 μ, diam. 2–3-plo longioribus? Cellulæ strati pseudoparenchymatici irregulares, angulatæ vel rotundatæ, 15–20 μ diam., in sporangia mutatæ. Sporangia irregularia 20–30 μ longa, sporis globosis numerosis (16–32 ?) 3–4 μ diam.

W. Falklands ; in frondibus *Nitophylli* sp., Shallow Bay, *Vallentin.*

The above new species occurred in abundance in a large sterile frond of an indeterminable species of *Nitophyllum*. It differs from *E. viride*, var. *Nitophylli*, Cotton, in the decidedly larger cells of the filaments, which also, for the most part, radiate across the cells of the host instead of following the outline of the cell-walls (*cf.* Pl. **6**. fig. 1, and Journ. Linn. Soc. xxxvii. pl. 12. fig. 1). A much larger amount of pseudoparenchyma is, moreover, developed in the present species, and in this sporangia arise in abundance (Pl. **6**. fig. 2).

UROSPORA PENICILLIFORMIS, *Aresch. Obs. Phyc.* I. p. 15.

Falkland Islands, teste *Gain.*

DISTRIB. N. temperate and Arctic regions, Fuegia (?), Kerguelen.

Gain gives this species in each of his lists as occurring in the Falkland Islands, but I have found no published record of the fact. It has, however, been recorded from other parts of the subantarctic.

RHIZOCLONIUM PACHYDERMUM, var. MACLOVIANUM, *Carlson, Süsswasser-algen aus der Antarktis*, p. 53, fig. 19.

E. Falklands ; Port Louis, *Skottsberg.*

DISTRIB. Falkland Islands.

Distinguished from the type by the unicellular rhizoidal branches, which are usually bifurcate at the tip.

CLADOPHORA FALKLANDICA, *Hook. f. et Harv. in Lond. Journ. Bot.* iv. (1845) p. 294 ; *Fl. Ant.* ii. p. 495, tab. 143. fig. 1.

E. Falklands ; Berkeley Sound, St. Salvador Bay, *Hooker.*

DISTRIB. Falkland Islands.

C. FLEXUOSA, *Dillw. Hist. Brit. Conf.* tab. 23.

E. Falklands ; Berkeley Sound, teste *Hooker.*

DISTRIB. N. Atlantic.

C. GRACILIS, *Kütz. Phyc. Germ.* p. 215.

W. Falklands ; Shallow Bay, at extreme low-water line, *Vallentin.*

DISTRIB. Throughout Europe, Atlantic coast of N. America, New Zealand, Tasmania (teste *Grunow*).

New to the Falkland area. The specimens are indistinguishable from those of southern England, and were procured from similar situations (*i. e.* quiet land-locked bays). *C. falklandica*, which is closely allied and may even be an extreme form, differs in the much shorter cells of the ultimate branches.

C. LÆTE-VIRENS, *Kütz. Phyc. Germ.* p. 214.

E. Falklands, *d'Urville*, teste *Hariot.* W. Falklands ; Roy Cove, *Vallentin.*

DISTRIB. North Atlantic.

Two specimens collected by Mrs. Vallentin are doubtfully referable to this species.

C. SUBSIMPLEX, *Kütz. Sp. Alg.* p. 41. *C. simpliciuscula*, Hook. f. et Harv. in Fl. Ant. ii. p. 496, tab. 142. fig. 4 (*non* Kütz.).

E. Falklands ; Berkeley Sound, *Hooker.*

The name given by Hooker & Harvey was preoccupied, hence Kützing renamed the plant in his 'Species Algarum.'

Cladophora arcta, *Kütz. Phyc. Gen.* p. 263.

E. Falklands; Berkeley Sound, Port William, *Hooker.* W. Falklands; West Point Island, *Vallentin, Hennis.*

Distrib. N. Atlantic, N.W. America, Fuegia, Kerguelen, South Georgia.

This species, around which in Northern Europe so many varieties and subspecies centre, is widely distributed in the subantarctic regions. The species was originally described by Dillwyn from Irish specimens, and on the Irish coasts numerous forms occur which pass imperceptibly into one another. Hence I regard with some misgivings the validity of most of the northern species which have recently been proposed, and likewise Kützing's *C. Hookeriana* from the Falkland Islands. Both Hooker's and Mrs. Vallentin's specimens are somewhat less dense than the commoner British forms, but they possess a copious supply of hooked branches and rhizoidal filaments. Gain ('12, p. 31) gives an interesting note on the structure of this species.

C. pacifica, *Kütz. Sp. Alg.* p. 419.

Falkland Islands, *Hohenacker,* no. 266.

Distrib. Auckland Island, Kerguelen, Fuegia.

See notes by Svedelius, '00, p. 295.

C. Hookeriana, *Kütz. Sp. Alg.* p. 418.

Falkland Islands, *Hooker.*

Distrib. Falkland Islands.

A form separated from *C. arcta* by Kützing. See note under that species.

C. confusa, *Hariot, in Bull. Soc. Bot. Fr.* xxxviii. (1891) p. 417 (note). *C. Kuetzingii*, Hariot, Miss. Cap Horn, p. 20 (*non* Ardiss.).

E. Falklands; Port Stanley, *Hohenacker.*

Distrib. Fuegia, Falkland Islands.

As his earlier name had been previously used by Ardissone, Monsieur Hariot re-named this species in 1891. In response to an enquiry he tells me that the full synonymy, according to Bornet, is as follows:—*C. confusa*, Hariot; *C. Kuetzingii*, Hariot (non Ardiss.); *C. repens*, Kütz. in Hohenacker, no. 411; *C. refracta*, Kütz. et *C. complicata*, Kütz., in Hohenacker, no. 468; *Lychæte tortuosa*, J. Ag. in Hohenacker, no. 253; *Rhizoclonium ambiguum* (Hook. f. & Harv.), Kütz. Sp. Alg. p. 387.

With regard to the last name given as a synonym, if this were correct a further change in nomenclature would have to be made, as Hooker & Harvey's name antedates all others. An examination of the type shows, however, that that plant is a true *Rhizoclonium* and not a *Cladophora,* hence it is not a synonym of Hariot's *C. confusa.*

Bryopsis plumosa, *Ag. Sp.* p. 448.

E. Falklands, teste *Hooker.*

Distrib. Recorded from all parts of the world, but many records require verification.

Most of Hooker's material is referable to *B. Rosæ*, and I am doubtful if any specimen can be identified with *B. plumosa* of Europe.

B. Rosæ, *Ag. Sp.* i. p. 450 ; *Hook. f. et Harv. in Fl. Ant.* ii. p. 492.

E. Falklands, *Hooker.* W. Falklands ; Shallow Bay, Roy Cove, *Vallentin* ; West Point Island, *Vallentin*, *Hennis.*

Distrib. Fuegia, Falkland Islands.

This species, which occurs so plentifully in the Falkland Islands and Magellan districts, was described by the elder Agardh in 1822, and, though closely allied to *B. plumosa* of Europe, it is usually regarded as a distinct species. The plant differs from *B. plumosa* in its larger size and more robust habit, but it is possible, as the authors remark in 'Flora Antarctica,' that it may be only "a large state of that very sportive species" (vol. ii. p. 492). They record, however, both species. A good series of spirit or formalin material is necessary if species of this genus are to be dealt with critically. Till the point can be definitely settled it is advisable to adhere to the old view. Part of the original gathering is to be found at Kew. It was collected by Gaudichaud about 1820, and was named after Rose de Freycinet, the heroic wife of the commander of the 'Uranie' expedition (see Oliver, '09, p. 210).

Codium difforme, *Kütz. Phyc. Gen.* p. 300.

W. Falklands ; Roy Cove, *Vallentin.*

Distrib. Mediterranean, Indian Ocean (Chagos Archipelago), Warmer Pacific (teste *Collins*), Kerguelen.

New to the Falklands. This plant has in the past been wrongly united with *C. adhærens*, and is presented thus in De Toni's 'Sylloge.' It resembles that species in habit, but differs in structure and also in geographical distribution. It is, on the whole, a rarer plant, and, with the exception of Hariot's ('89) record which may possibly concern *C. adhærens*, has not been previously recorded from this region. A specimen from Kerguelen also exists, being collected during the 'Challenger' expedition and found un-named in the Kew Herbarium. The utricles of *C. difforme* measure 1 mm. by 150–200 (rarely 300) μ and are much longer and larger than those of *C. adhærens*, as was pointed out by Kützing (Tab. Phyc. vi. fig. 99) and later by Askenasy & Bornet.

CODIUM MUCRONATUM, *J. Ag. Till Alg. Syst.* viii. p. 43. *C. tomentosum*, Hook. f. et Harv. in Fl. Ant. ii. p. 491 (*non* Stackh.).

E. Falklands ; Berkeley Sound, Port William, St. Salvador Bay, *Hooker* ; Port Stanley, *Vallentin.* W. Falklands ; Roy Cove, Shallow Bay, King George's Sound, on rocks near low-water line, *Vallentin* ; West Point Island, *Hennis.*

DISTRIB. Australia, New Zealand, Fuegia. Pacific coast of N. America (var. *californicum*), Japan (?), Scotland, and Ireland (var. *atlanticum*).

This plant is evidently common in the Magellan region. Several specimens collected by various expeditions exist at Kew, and a fine series was brought home by Mrs. Vallentin. The alga was listed by Hooker as *C. tomentosum* and referred to by Hariot in 1889 as *C. fragile*, a Japanese species (or form ?) to which it is very closely allied. It is, however, undoubtedly the same as J. Agardh's *C. mucronatum*, which was described three years previously from Australia and New Zealand, as, indeed, Svedelius has already pointed out ('00, p. 299). The Falkland Island material agrees for the most part with var. *Novæ Zelandiæ*, J. Ag., but two specimens approach very closely var. *tasmanicum*. Whether these forms are worthy of varietal names is questionable.

The discovery of *C. mucronatum* on the west coasts of Scotland and Ireland a few years ago was interesting and unexpected, since the plant is not known elsewhere in Europe. A fairly full account of its biology and distribution is given in the report on the Marine Algæ of the Clare Island Survey (Cotton, '12, pp. 114–119).

OSTREOBIUM QUEKETTI, *Born. et Flah. in Bull. Soc. Bot. France*, xxxvi. (1889) p. clxi, pl. 9. figs. 5–8.

W. Falklands, *Vallentin.*

DISTRIB. Europe, N. America, probably cosmopolitan.

Some very fine material, apparently indistinguishable from the European form, was found in some shells collected by Mrs. Vallentin in the West Falklands.

PHÆOPHYCEÆ.

DURVILLEA ANTARCTICA, *Hariot, in Notarisia*, vii. (1892) p. 1432. *D. utilis*, Bory in d'Urville, Flore des Malouines, p. 588 ; Hook. f. et Harv. in Fl. Ant. ii. p. 454.

E. Falklands, *Hooker* ; Kidney Cove, *Skottsberg.* W. Falklands, *Vallentin* ; Cape Meredith, *Skottsberg.*

DISTRIB. Chile (Magellan–Valparaiso), Fuegia, Falkland Islands, S. Georgia, Kerguelen, Tahiti (teste *Grunow*), New Zealand, Chatham Islands, Auckland Island, Campbell Island.

The correct name for this plant was first given by Hariot in 1892, a fact overlooked by Skottsberg.

"Dark myrtle-green in colour, occurring along the shores of the open ocean, where it appears to revel in the boisterous surf. During low-water spring tides, the long finger-like fronds are left stranded on the rocks, and on the return of the tide they afford a pretty sight being washed hither and thither by the waves."

DURVILLEA HARVEYI, *Hook. f. in Lond. Journ. Bot.* iv. (1845) p. 249.

Falkland Islands, *Hooker*, *Skottsberg*. W. Falklands, *Vallentin*.

DISTRIB. Fuegia, Falkland Islands, S. Georgia (?), Kerguelen.

The following notes by Mrs. Vallentin are worthy of record :—

"The second species of *Durvillea*, *D. Harveyi*, flourishes in similar regions to the preceding and is similar in colour, but the fronds are broad and not split up to the same extent. The whole plant resembles rather a sheet of leather, and grows to a very large size. In the largest specimen we noted, which was washed ashore in King George's Sound, the stem when fresh measured 8½ inches in circumference, and the whole plant was so massive that I could not move it. I therefore fastened my horse to the stem and dragged it up above high-water mark. On spreading the fronds out on the turf, it was found to cover a space measuring 12 × 18 feet, the size of an ordinary sitting-room. The most striking feature about this plant is the strong, short stem, seldom, if ever, exceeding 6 inches in length, which is fastened to the sucker-like root by a kind of ball-and-socket joint, which allows the fronds to sway about in the waves (*vide* Pl. 6). The fronds of both species when dry present an appearance similar to honey-comb, and I am informed that the dried fronds of *Durvillea utilis*, when cleaned out, are used as water-bottles in some parts of the South American continent."

ADENOCYSTIS UTRICULARIS, *Skottsb. Subant. u. Ant. Meeresalgen*, i. p. 39.

A. Lessonii, Hook. f. et Harv. in Fl. Ant. i. p. 179, tab. 69. fig. 2; ii. p. 468.

E. Falklands; Berkeley Sound, *Hooker*; Port Louis, littoral pools and rocks, *Skottsberg*. W. Falklands; West Point Island, *Hennis*.

DISTRIB. Fuegia, Falkland Islands, S. Shetlands, S. Orkneys, Louis Philippe Land, Cockburn Island, S. Georgia, Kerguelen, Tasmania, New Zealand, Auckland Island, Campbell Island.

Gain ('12) gives a good account of this plant. He uses the more familiar name *A. Lessonii*, but, since Bory's *Asperococcus utricularis* antedates his *A. Lessonii* by two years, the combination employed by Skottsberg is correct.

LESSONIA NIGRESCENS, *Bory in Duperry, Voy. Bot. Crypt.* p. 80, tab. 5.

E. Falklands, *Hooker*; Port William, *Skottsberg*. W. Falklands; Roy Cove, in rock-pools, *Vallentin*.

DISTRIB. Peru, Chile, Fuegia, Falkland Islands, S. Georgia (?), Kerguelen, Heard Island, Tahiti (teste *Grunow*).

LESSONIA FLAVICANS, *Bory in d'Urville, Flore des Malouines*, p. 594 (1826); *Skottsberg, Subant. u. Ant. Meeresalgen*, i. p. 73, Taf. 7, text-figs. 89–90. *L. fuscescens*, Bory; Hook. f. et Harv. in Fl. Ant. ii. p. 457. *L. ovata*, Hook. f. et Harv. *l. c.* p. 459.

E. Falklands, *Hooker*; Berkeley Sound, Port Louis, *Skottsberg*.

DISTRIB. Chile (Valparaiso–Magellan), Fuegia, Falkland Islands, S. Georgia, Kerguelen, Heard Island.

No algologist has had such good opportunities for studying these plants as Dr. Skottsberg, and we must take his verdict that the debatable *L. ovata*, Hook. f. & Harv., is not specifically distinct from *L. flavicans* (= *L. fuscescens*). Skottsberg goes into the question of synonymy, and gives a good and illustrated account of the anatomical structure of both this and the two other Falkland Islands species.

L. FRUTESCENS, *Skottsb. Subant. u. Ant. Meeresalgen*, i. p. 78, Taf. 8.

E. Falklands; Berkeley Sound, Port Louis, Port Stanley, *Skottsberg*.

DISTRIB. Falkland Islands.

In contrast to *L. flavicans* and *L. frutescens* this species is found in the uppermost part of the sublittoral region and is exposed at dead low-water.

MACROCYSTIS PYRIFERA, *Ag. Sp.* i. p. 46.

Falkland Islands; general, all collectors.

DISTRIB. Galapagos Islands to Cape Horn, Fuegia, Patagonia, Falkland Islands, S. Georgia, Tristan da Cunha, Cape of Good Hope, Prince Edward Island, Crozets, St. Paul, New Amsterdam, Kerguelen, W. & S. Australia, Tasmania, New Zealand, Chatham Islands, Auckland Island, Campbell Island, Tahiti (*teste* Grunow); W. Coast N. America (Sitka–S. California), Okhotsk Sea, Aleutian Islands.

The classical account of this wonderful plant is to be found in the pages of the 'Flora Antarctica.' Hooker brings together 10 species under one name, and shows that the variation displayed at different localities is a matter of habitat. After a summary of the history of the alga he narrates his own observations in the Antarctic, and concludes with a paragraph on its interesting distribution. Circling the globe in the southern temperate and subantarctic zones, and stretching up with the Humboldt Current on the west coast of South America as far as the equator, the plant is found also in the Northern hemisphere from Alaska down to S. California. In the Atlantic and Indian Oceans, on the other hand, it is confined to the southern waters.

As regards the length of the fronds, Mrs. Vallentin writes:—"In the 'Flora Antarctica' Hooker stated that some of the plants which grew in Christmas Harbour, Kerguelen Island, were more than 300 feet long; and elsewhere near the same island, some specimens were estimated to measure 700 or even 1000 feet in length. Along the shores of this archipelago,

according to our observations, *Macrocystis* does not nearly approach these dimensions. The largest stranded specimen I have seen was one thrown on the shore of Port North beach after a heavy gale. The basket-like root measured exactly 36 inches in diameter, and the total length of the plant when stretched out along the shore was 195 feet. On one occasion while steaming up Falkland Sound I had exceptional opportunities, owing to the calmness of the sea, of making some fairly accurate observations as to the approximate lengths of floating specimens. We were steaming near Swan Island, where the water was never less than 16 fms. in depth, and the long trailing stems and fronds of this seaweed floated on the calm surface of the sea. Besides being a complete calm, it was slack water, so that the observations were made with a tolerable degree of accuracy. Taking the length of the steamer as 70 feet, and the depth of the water as 16 fathoms, the captain and I arrived at the independent conclusion that these examples of *Macrocystis* measured between 150 and 170 feet in length."

Skottsberg devotes 59 pages to *Macrocystis*, and his account is practically a memoir on the morpholgy and anatomy of the genus, though notes on the biology, phylogeny, and a review of the varieties and forms that have been described, are included.

In the work on Peru algæ just published by Howe ('14) it will be seen that he is inclined to believe that "two reasonably distinct species" of *Macrocystis* occur on the west coast of South America (pp. 60–66).

Cæpidium antarcticum, *J. Ag. in Hohenacker, Alg. exsicc.* no. 320; *Till Alg. Syst.* iv. p. 60.

E. Falklands; Port Stanley, *Hohenacker*; Port Louis, upper sublittoral and littoral rocks and pools, *Skottsberg.*

Distrib. Falkland Islands, S. Georgia.

This curious alga, described from rather scanty material by J. Agardh, remained little known till rediscovered by Skottsberg. The latter gives descriptions of its early stages, and then proceeds to point out a most remarkable dimorphism, namely the possession of *Colpomenia*-like shoots. Agardh noted that it had a prostrate thallus and described rather vaguely the upright fertile shoots, and Skottsberg believes that the bladder-like structures found on it are also part of the plant itself.

Having regard to the wealth of preserved material studied by Skottsberg, one would be inclined to accept this conclusion in spite of its being so unexpected. Dr. Yendo, however, who has examined Agardh's material, assures me that he cannot accept Skottsberg's interpretation of the genus. The type according to Yendo is a *Chordaria* which possesses creeping branches and upright shoots. One specimen lacks the upright branches, but the other has several, and resembles very much an old and nearly decayed plant of *Chordaria abietina* (*cf.* Setchell & Gardiner, pl. 18, figs. 16 & 17).

Yendo maintains that the bladder-like fronds are quite distinct from the so-called fertile axis, and that they consist of young plants of *Colpomenia sinuosa* or an allied species.

In view of Dr. Yendo's intimate knowledge of the life-histories both of *Chordaria* and *Colpomenia* in the North Pacific, I feel bound to accept this conclusion, and believe that Dr. Skottsberg must have been misled, as have been other observers in similar cases, by the intimate connection of host and epiphyte. As it has not been possible to identify the *Chordaria*, the alga is here left under the old name *Cœpidium*. (See notes under *Colpomenia sinuosa*.)

Myrionema macrocarpum, *Skottsb. Subant. u. Ant. Meeresalgen*, i. p. 49.
E. Falklands; Berkeley Sound, on *Macrocystis* and *Lessonia*, *Skottsberg*.
Distrib. Falkland Islands.

M. densum, *Skottsb. l. c.* p. 50.
E. Falklands; Berkeley Sound, on *Macrocystis* and *Lessonia*, *Skottsberg*.
Distrib. Falkland Islands.

Chordaria capensis, *Kütz. Tab. Phyc.* viii. p. 5, tab. 11.
W. Falklands; West Point Island, *Vallentin*, *Hennis*.
Distrib. Cape of Good Hope, Fuegia, Kerguelen.

This species may be considered as rare in the islands, as it was not found by Skottsberg or any previous collector. The five specimens brought home by Mrs. Vallentin agree with the Cape species rather than with *C. flagelliformis*, and it is probable that all the records of the latter from Fuegia refer to this species.

C. linearis, *Cotton*, comb. nov. (Pl. **5**; Pl. **6**. figs. 3 & 4.) *Mesogloia linearis*, Hook. f. et Harv. in Hook. Lond. Journ. Bot. iv. (1845) p. 251; Fl. Ant. ii. p. 470.
W. Falklands; West Point Island, *Hennis*.
Distrib. Fuegia, Falkland Islands.

The plant described by Hooker & Harvey as *Mesogloia linearis* has remained little known. Several plants were collected by the 'Erebus' and 'Terror' Expedition, but they were rather young and, as shown by comments on herbarium sheets, later algologists have doubted the validity of the species.

The structure of the stem is not that of *Mesogloia*, but rather that of *Chordaria*, though the frond is less firm and the tissue less parenchymatous than in *C. flagelliformis*. In habit the plant strongly resembles *Dictyosiphon fœniculaceus*, but is much more robust, the main stem in the dried specimen being as much as 1·5 mm. in diameter in an old plant.

The full and revised description of this species, which is illustrated on Plates **5** & **6**, is as under : —

Plants single or cæspitose, rather large, much branched, mucilaginous, brownish green when dried. Main shoots slender, 20–25 cm. long, 1–1·5 mm. diam., densely clothed with slender branches. Branches similar to main shoots, beset with scattered, scarcely branched ramuli. Structure of stem loosely cellular; cells 15–20 μ diam. intermixed with slender filaments 7–9 μ thick. Assimilating filaments club-shaped, 5–7-celled, densely packed, 50–70 μ long, 10–12 μ wide at apex. Hairs absent? Unilocular sporangia obovate, 45–50 × 22–25 μ.

Leptonema falklandicum, *Skottsb. Subant. u. Ant. Meeresalgen*, i. p. 52.

E. Falklands; Port Louis, on *Rhodomela* in pools, *Skottsberg.*

Distrib. Falkland Islands.

Scytothamnus rugulosum, *Kjellm. in Engler u. Prantl, Natürl. Pflanzenf.* Teil i. Abt. 2, p. 214. *Rhodomela rugulosa*, Bory, Flore des Malouines, p. 593. *Stereocladon Lyallii*, Hook. f. et Harv. in Fl. Ant. ii. p. 468, tab. 174.

E. Falklands ; Berkeley Sound, *Hooker* ; Port Louis, *Skottsberg.* W. Falklands ; Shallow Bay, *Vallentin* ; West Point Island, *Hennis.*

Distrib. Fuegia, Falkland Islands, S. Orkney, Kerguelen.

S. fasciculatus, *Cotton*, comb. nov. *Dictyosiphon fasciculatus*, Hook. f. et Harv. in Fl. Ant. i. p. 178; ii. p. 467. *Scytothamnus australis,* Skottsb. *l. c.* p. 48, *non* Hook. f. et Harv.

E. Falklands, *Hooker*, *Vallentin.*

Distrib. Fuegia, S. Georgia, Kerguelen, Auckland Island.

This plant belongs to the genus *Scytothamnus*, as was hinted by De Toni. Skottsberg with some reservation links it with *S. australis*, but, from an examination of several specimens in the Hooker herbarium, it appears to me to be a good and distinct species. For the present therefore it seems best to retain the old specific name. *S. fasciculatus* differs from *S. australis* in being a much more slender plant with a different method of branching, and having a more southern range. Presumably all the plants collected by Skottsberg in the antarctic belong to this species, and not to *S. australis.*

Desmarestia Willii, *Reinsch, in Flora*, xlvi. (1888) p. 188. *D. viridis*, Hook. f. et Harv. in Fl. Ant. ii. pp. 178, 466 (*non* Lamx.).

E. Falklands ; Berkeley Sound, Port William, *Hooker* ; Port Louis, *Skottsberg.* W. Falklands; Shallow Bay, Roy Cove, in sublittoral region and in pools, *Vallentin* ; West Point Island, *Hennis.*

Distrib. Fuegia, Falkland Islands, S. Georgia, Marion Island, Kerguelen, Auckland Island, Victoria Land, Franklin Island.

This species is apparently common in Fuegia and the Falkland Islands.

It was formerly regarded as the same as the European *D. viridis*, to which it is certainly very closely allied. Reinsch in 1888 referred the South Georgian specimens of the German South Polar Expedition of 1882–3 to a distinct species, *D. Willii*, and Skottsberg, who has had ample opportunities of examining the plant in the growing condition, agrees with him and regards all the subantarctic material previously referred to *D. viridis* as belonging to this species. *D. Willii* has a wide range in the subantarctic and was found in plenty by Mrs. Vallentin in the West Falklands.

DESMARESTIA HARVEYANA, *Gepp, in Journ. Bot.* xliii. 1905, p. 106 (figs. 11–15). *D. media*, Hook. f. et Harv. in Fl. Ant. ii. p. 466 (*non* Grev.). *D. compressa*, Skottsb. Subant. u. Ant. Meeresalgen, i. p. 19.

E. Falklands, *Lyall* (teste *Skottsberg*).

DISTRIB. Falkland Islands, S. Georgia, Graham Land.

According to the International Rules there was no occasion to change the name proposed by Mr. and Mrs. Gepp in favour of *D. compressa*, Skottsb. The evidence of the occurrence of the plant in the Falklands rests on Skottsberg's note (*l. c.* p. 19).

D. ROSSII, *Hook. f. et Harv. in Lond. Journ. Bot.* iv. (1845) p. 249.

E. Falklands; Port William, *Hooker*, *Skottsberg*. W. Falklands; Roy Cove, Fox Bay, West Point Island, Saunders Island, *Vallentin*; Carcass Island, *Hennis*.

DISTRIB. Fuegia, Falkland Islands, Heard Island, South Orkney, Victoria Land.

Mrs. Vallentin, who collected several large specimens of this fine and distinct species, writes that "the plant is locally known as 'Fern Kelp,' and is rare at the present time. It occurs at West Point Island, Roy Cove, and the north side of Saunders Island, where it is occasionally torn off and washed ashore after gales, together with *Durvillea*, *Lessonia*, and *Macrocystis*. We have only once seen this species growing, that being at Gentoo rookery beach, Fox Bay, where it was exposed at extreme low-water. We hunted in vain for the plant at Berkeley Sound."

D. LIGULATA, *Lamour. Ess.* p. 25; *Hook. f. et Harv. in Fl. Ant.* ii. p. 467.

Falkland Islands, *Gaudichaud*; West Point Island, *Hennis*.

DISTRIB. Apparently general in the colder seas of both the N. and S. hemispheres.

As far as can be seen, the South American specimens differ in no way from those of Northern Europe.

D. FIRMA, *Skottsb. l. c.* p. 21, figs. 15–17. *D. ligulata*, var. *firma*, J. Ag. Sp. Alg. i. p. 169.

Falkland Islands, teste *Skottsberg*.

Distrib. Chile, Fuegia, Falkland Islands, S. Georgia, Cape of Good Hope.

The distribution is that given by Skottsberg, who raises *D. ligulata*, var. *firma*, J. Ag., to specific rank. I am not clear as to the limits of this species as defined by him.

Stictyosiphon Decaisnii, *G. Murr. in Journ. Bot.* xxiv. (1891) p. 196. *Cladothela Decaisnii,* Hook. f. et Harv. in Fl. Ant. ii. p. 491.

E. Falklands; Berkeley Sound, *Hooker*; Port Stanley, *Vallentin*; Port Louis, in pools in littoral region, *Skottsberg.*

Distrib. Fuegia, Falkland Islands, S. Georgia.

? Punctaria plantaginea, *Grev. Alg. Brit.* p. 53.

E. Falklands; Port Louis, *Skottsberg.*

Distrib. Atlantic and Arctic Oceans, Fuegia, Falkland Islands.

Skottsberg found a few plants which he referred, with some reservation, to this species.

Corycus prolifer, *Kjellman in Engl. u. Prantl, Natürl. Pflanzenf.* Teil i. Abt. 2, p. 202, *pro parte. Punctaria lanceolatum,* Kütz. Sp. Alg. p. 484 (?).

E. Falklands; Berkeley Sound, *Hooker, Skottsberg*; Port William, *Hooker, Arnott*; Port Louis, *Skottsberg*; Port Stanley, *Vallentin.*

Distrib. Chile, Fuegia, Falkland Islands, S. Georgia.

See note on *Punctaria lanceolatum* on p. 200.

Scytosiphon lomentarius, *J. Ag. Sp.* i. p. 126.

E. Falklands; Berkeley Sound, *Hooker, Vallentin*; Port Louis, *Skottsberg.* W. Falklands; Shallow Bay, West Point Island, on rocks near low water, *Vallentin.*

Distrib. General in temperate and cold seas, but not known from the tropics.

This, together with *Phyllitis fascia,* is one of the few well-marked and fairly large Falkland Phæophyceæ which is very widely distributed. Hooker found it plentifully at Berkeley Sound, and Mrs. Vallentin collected well-grown specimens in the Western islands.

S. crispus, *Skottsb. Subant. u. Ant. Meeresalgen,* i. p. 35.

E. Falklands; Port Louis, *Skottsberg.*

Distrib. Falkland Islands.

A small species detected by Skottsberg and only known from one locality.

Phyllitis fascia, *Kütz. Phyc. Gen.* p. 342.

E. Falklands; Berkeley Sound, *Hooker*; Port Louis, in pools and shallow sublittoral, *Skottsberg.*

Distrib. Atlantic and Arctic Oceans, Mediterranean, North Pacific (Japan and America), S. Peru, Fuegia, Falkland Islands, S. Georgia.

The forms assumed in the subantarctic are very similar to those found in Europe.

Colpomenia sp. *Asperococcus sinuosus*, Hook. f. et Harv. in Fl. Ant. ii. p. 468.

E. Falklands; Berkeley Sound, *Hooker*. W. Falklands; Roy Cove, *Vallentin*.

Distrib. Falkland Islands, S. Georgia, Kerguelen (?).

See notes under *Cæpidium antarcticum*, p. 168. Skottsberg's account of the bladder-like shoots seem to prove that the plant cannot be referred to *Colpomenia sinuosa*. The forked basal branches described by him would appear to be part of the *Colpomenia* plant (and not of the *Chordaria*), and these are unlike anything found in the ordinary *Colpomenia* of Europe. Skottsberg refers to Mitchell's account, and gives other reasons (p. 44) why he cannot identify it with the *C. sinuosa* of warmer seas. It may be noted here, however, that, since the publication of his report, *Colpomenia* has appeared in the English Channel, and from the variability in the distribution of the sporangia and tufts of hairs shown by British material, it is evident that some of the reasons advanced by Skottsberg will have to be reconsidered, and that before it is possible to express a definite opinion on the identity of the various extra-European forms a detailed morphological and anatomical study of old *C. sinuosa* of the Mediterranean is necessary.

Mrs. Vallentin collected several specimens at Roy Cove, but from dried material it is impossible to throw further light on so difficult a problem. Pending further investigation of preserved material I have left the plant as *Colpomenia* sp.

Utriculidium Durvillei, *Skottsb. Subant. u. Ant. Meeresalgen*, i. p. 36. *Adenocystis Durvillæi*, Hook. f. et Harv. in Fl. Ant. ii. p. 468.

E. Falklands; Port Louis, Port Stanley, *Skottsberg*.

Distrib. Fuegia, Falkland Islands, S. Georgia, Kerguelen.

On the ground of the plurilocular sporangia Skottsberg separates *Adenocystis Durvillei* from *A. utricularis*, Skottsb. (=*A. Lessonii*, Hook. et Harv.), and raises it to generic rank. There appear to be no specimens of this species in the Kew Herbarium.

Sphacelaria furcigera, *Kütz. Tab. Phyc.* v. p. 27, tab. 90.

E. Falklands; Port Louis, *Skottsberg*.

Distrib. Probably cosmopolitan.

Cladostephus setaceus, *Suhr, in Flora*, xix. (1836) p. 347. *C. spongiosus*, Hook. f. et Harv. in Fl. Ant. ii. p. 469 (*non* Ag.).

E. Falklands ; Port William, Berkeley Sound, *Hooker* ; Port Louis, *Skottsberg*.

DISTRIB. Fuegia, Falkland Islands, Australia (?), Tasmania (?).

Skottsberg shows that Harvey's *C. spongiosus* from the Falklands is Suhr's *C. setaceus*, which he states is synonymous with Kützing's *C. antarcticus*. He remarks that the plant is common in the sublittoral zone down to a depth of 18 fathoms.

HALOPTERIS OBOVATA, *Sauv. in Journ. de Bot.* xviii. (1904) p. 92. *Sphacelaria obovata*, Hook. f. et Harv. in Fl. Ant. ii. p. 469.

E. Falklands; Port Louis, *Skottsberg*.

DISTRIB. Fuegia, Falkland Islands, S. Georgia.

This species was wrongly united by De Toni, Syll. Ag. iii. p. 517, with *Stypocaulon funiculare*.

H. FUNICULARIS, *Sauv. in Journ. de Bot.* xvii. (1903) p. 334.

Falkland Islands, *Skottsberg*.

DISTRIB. Fuegia, S. Georgia, Tristan da Cunha, Australia, New Zealand, Auckland Island.

PYLAIELLA LITORALIS, *Kjellman, Bidr. Skand. Ectocarp.* p. 99.

E. Falklands ; Port Louis, Duperrey Harbour, *Skottsberg*.

DISTRIB. Cosmopolitan.

ECTOCARPUS SILICULOSUS, *Lyngb. Hydrophyt. Dan.* p. 131 ; *Hook. f. et Harv. in Fl. Ant.* ii. p. 469.

E. Falklands ; Berkeley Sound, *Hooker* ; Port Stanley, *Vallentin* ; Port Louis, *Skottsberg*.

DISTRIB. Cosmopolitan.

E. CONSTANCIÆ, *Hariot, in Journ. de Bot.* i. (1887) p. 56.

E. Falklands ; epiphytic in sublittoral region and in pools, *Skottsberg*.

DISTRIB. Fuegia, Falkland Islands, S. Georgia, Kerguelen.

E. EXIGUUS, *Skottsb. Subant. u. Ant. Meeresalgen*, i. p. 5. *E. humilis*, Reinsch, Meeresalg. Südgeorg. p. 411.

E. Falklands ; Port Louis, *Skottsberg*.

DISTRIB. Fuegia, Falkland Islands, S. Georgia.

E. FALKLANDICUS, *Skottsb. l. c.* p. 5.

E. Falklands ; Port Louis, *Skottsberg*.

DISTRIB. Falkland Islands.

E. PECTINATUS, *Skottsb. Subant. u. Ant. Meeresalgen*, i. p. 11.
E. Falklands ; Port Louis, on *Cladophora*, *Skottsberg*.
DISTRIB. Falkland Islands.

GEMINOCARPUS GEMINATUS, *Skottsb. l. c.* p. 13. *Ectocarpus geminatus*, Hook. f. et Harv. in Fl. Ant. ii. p. 469.
E. Falklands ; abundant, *Hooker* ; Port Louis, general, very luxuriant, clothing stones, mussels, and other algæ in littoral and sublittoral region, *Skottsberg*. W. Falklands ; West Point Island, *Vallentin*.
DISTRIB. Fuegia, Falkland Islands, Graham Land, S. Georgia, Kerguelen, Victoria Land.

FLORIDEÆ.

PORPHYRA UMBILICALIS, *Kütz. Phyc. Gen.* p. 383. *P. vulgaris*, Ag. ; Hook. f. et Harv. in Fl. Ant. ii. p. 500.
Falkland Islands, abundant, all collectors.
DISTRIB. Cosmopolitan.
Both the short umbilicate and long laciniate forms occur.

P. LEUCOSTICTA, *Thur. in Le Jol. List Alg. Cherb.* p. 100.
Falkland Islands, *Hooker*.
DISTRIB. Atlantic and Mediterranean.
The presence of this species is doubtful, but Hariot lists a Hooker specimen in his Cape Horn memoir.

CONCHOCELIS ROSEA, *Batters in G. Murr. Phyc. Mem.* i. (1892) p. 27, tab. 7.
W. Falklands ; in shells, Roy Cove, *Vallentin*.
DISTRIB. Probably cosmopolitan.
Frequent in shells, and, as far as could be seen, indistinguishable from European material.

CHÆTANGIUM FASTIGIATUM, *J. Ag. Sp.* i. p. 460. *Halymenia fastigiata*, Bory, Fl. des Malouines, no. 23. *Nothogenia variolosa*, Mont. ; Hook. f. et Harv. in Fl. Ant. ii. p. 487, *pro parte*.
E. Falklands ; Berkeley Sound, *Hooker* ; Port Stanley, *Vallentin, Hohenacker*. W. Falklands ; Roy Cove, *Vallentin*.
DISTRIB. Fuegia, Kerguelen.
It appears possible that *Chætangium variolosum*, described by Montagne from Auckland Island in 1842, is merely a large full-grown example of *C. fastigiatum*, which was originally described by Bory from the Falkland Islands (1828). In any case, with one exception, all the South American and Falkland Islands specimens in the Kew Herbarium, though labelled

C. variolosum, belong rather to *C. fastigiatum*, and the same applies to the Kerguelen specimens. The exception (a Hooker specimen from Magellan) is intermediate in form and would appear to be composed of loose tissue in the young fronds, which becomes dense and compact later. Hohenacker's *Dumontia fastigiata*, var. *minor*, Exsicc. 282, from the East Falklands, is, in the British Museum set, a small specimen only, but clearly not referable either to *Dumontia* or *Chætangium*.

Chætangium variolosum, *J. Ag. Sp.* p. 461. *Nothogenia variolosa*, Mont.; Hook. f. et Harv. in Fl. Ant. ii. p. 487, *pro parte*.

E. Falklands; Berkeley Sound, teste *Hooker*.

Distrib. Auckland Island, Fuegia (?), Kerguelen (?).

See note under *C. fastigiatum*.

Gelidium crinale, *J. Ag. Epicr.* p. 546.

Falklands; Herb. Lenormand, *Lesson*, teste *Hariot*.

Distrib. North Atlantic (Europe and America), Mediterranean, Queensland.

This plant is probably more widely distributed than generally supposed. Specimens were recently received at Kew from Queensland, the first record for the continent of Australia.

? Chondrus crispus, *Lyngb. Hydrophyt. Dan.* p. 15.

Falklands, *Gaudichaud*.

Distrib. North Atlantic (Europe and America), Japan. Graham Land.

The only evidence of this plant having been found in the Falkland Islands is Gaudichaud's specimen in the Paris Museum. Hariot (*l. c.* p. 62) was inclined to believe that the locality might have been incorrect; but, as Gain states that a plant indistinguishable from this species is plentiful in the islands off Graham Land, it is possible that it extends also to higher latitudes.

Iridæa cordata, *J. Ag. Sp.* ii. p. 254; *Hook. f. et Harv. in Fl. Ant.* ii. p. 485. *I. laminarioides*, Bory, Voy. 'Coquille,' p. 105. *I. micans*, Bory, *l. c.* p. 110.

Falkland Islands; general, all collectors.

Distrib. Chile, Fuegia, Graham Land, S. Georgia, Victoria Land. North Pacific (Alaska–California).

I have followed Gain, who unites *I. micans* with *I. cordata*. Hooker and Harvey held this view, though subsequently treated them as distinct. Gain gives a useful history of the plant, together with a full list of synonyms. From his account one would be almost justified in assuming that all the so-called species of the genus from South America and the Subantarctic are merely forms of the exceedingly variable *I. cordata*.

Professor W. A. Setchell, who more than anyone else has studied *Iridæa* in the living state, likewise believes, though he adopts a slightly different nomenclature, that most of the so-called species cannot be maintained. He kindly examined two of the extreme forms found by Mrs. Vallentin in the Falkland Islands, and in a letter concerning them expresses his views as follows:—

"So far as I can make out, the only real point of difference between *Iridæa micans* and *Iridæa laminarioides* is to be found in the slightly broader base of the former, together with its serrulate margin. From my experience of this genus on the coast of California, I am not inclined to believe that either character is a constant one. I have watched *Iridæa* species through the year, and found that they vary. I have found a serrulated-margined specimen in the midst of a clump with entire margins. I found according to the exposure, depth of water, etc., that the texture and shade of colour varied so much that all I can do at present is to refer these various species as forms, or at most varieties, under *Iridæa laminarioides*. The one species I feel at all certain of being able to distinguish from *Iridæa laminarioides* is *I. Augustinæ*. That has a rough surface, but at times it is smooth except very near the base. . . . . Consequently my opinion would be that your plants are forms or varieties of *Iridæa laminarioides*, but if you prefer that they may be separated from this species, they are to be referred to *Iridæa micans*."

Professor Setchell further remarks: "As you are probably aware, I am inclined to refer even the *cordata* series to *Iridæa laminarioides*"; and in his work on the Algæ of North-West America he places *I. cordata* as a form of that species.

Gigartina radula, *J. Ag. Alg. Liebm.* p. 12; *Sp.* ii. p. 278. *Iridæa radula*, Bory, Voy. 'Coquille,' p. 107; Hook. f. et Harv. in Fl. Ant. ii. p. 485.

Falklands; general, all collectors.

Distrib. Fuegia, Falkland Islands, Kerguelen, Islands off Louis Philippe's Land and Graham Land, New Zealand, Auckland Island, Campbell Island. Cape of Good Hope. N. Pacific (Vancouver–California).

Several portions of very large fronds were brought home by Mrs. Vallentin, and also young and entire plants. The majority possess cystocarps in the usual apiculate tubercles, but a few fronds contain tetrasporic sori; and the latter are rough with small papillæ, though the sori themselves are for the most part embedded in the substance of the fronds.

Phyllophora cuneifolia, *Hook. f. et Harv. in Lond. Journ. Bot.* iv. (1845) p. 260; *Fl. Ant.* ii. p. 486. (Pl. 7.)

E. Falklands; Port William, St. Salvador Bay, *Hooker*. W. Falklands; West Point Island, *Vallentin*, *Hennis*.

Distrib. Falkland Islands, Kerguelen (?).

A rare and little-known plant. The species is based on Hooker's Falkland Islands specimens, and has not been found since. Two doubtful gatherings from Kerguelen exist at Kew, one of which is named and recorded by Hooker, but the plant differs considerably from the type, and is, indeed, marked by him with a query.

De Toni (Syll. Alg. iv. p. 257) has cast doubt on the generic position of the species. A photograph of one of the two original specimens at Kew is reproduced on Plate **7**; the other specimen, from St. Salvador Bay, is less elongated and has broader fronds. From the form and structure of these specimens the plant appears to be a genuine *Phyllophora*, though, as both are sterile, it is impossible to speak with certainty. The specimens collected at West Point Island, referred with some doubt to this species, are also sterile.

AHNFELTIA PLICATA, *Fr. Fl. Scan.* p. 310. *Gigartina plicata*, Grev.; Hook. f. et Harv. in Fl. Ant. ii. p. 487.

E. Falklands; in herb. Lenormand, teste *Hariot*; St. Salvador Bay, Cape Pembroke, *Hooker*; Port Stanley, *Hohenacker*, no. 555. W. Falklands; West Point Island, *Vallentin*.

DISTRIB. North temperate and Arctic regions. Fuegia, S. Georgia, Kerguelen.

Hariot unites *Gracilaria? aggregata*, Hook. f. et Harv., with the present species, but, as explained below (p. 179), this course cannot be adopted.

STERROCOLAX DECIPIENS, *Schmitz, in Flora*, lxxvii. (1893) p. 397.

E. Falklands; on *Ahnfeltia plicata*, Port Stanley, *Hohenacker*, no. 555.

DISTRIB. Probably the same as *Ahnfeltia plicata*.

CALLOPHYLLIS FASTIGIATA, *J. Ag. Epic.* p. 229. *Rhodymenia sobolifera*, Hook. f. et Harv. in Fl. Ant. ii. p. 475 (*non* Greville).

Falkland Islands; general, most collectors.

DISTRIB. Fuegia, Falkland Islands, Kerguelen.

C. VARIEGATA, *Kütz. Phyc. Gen.* p. 400. *Rhodymenia variegata*, Mont.; Hook. f. et Harv. in Fl. Ant. ii. p. 475, *excl.* var. β et γ.

Falkland Islands; general, all collectors.

DISTRIB. Peru, Chile, Fuegia, Falkland Islands, S. Orkneys, Graham Land, Kerguelen.

C. ATRO-SANGUINEA, *Hariot, in Journ. de Bot.* i. (1887) p. 73; *Miss. Cap Horn*, p. 75, pls. viii. & ix. *Rhodymenia variegata*, var. β. *atro-sanguinea*, Hook. f. et Harv. in Fl. Ant. ii. p. 476.

E. Falklands; Cape Pembroke, *Hooker*. W. Falklands; West Point Island, *Vallentin*, *Hennis*.

DISTRIB. Fuegia, Falkland Islands, Kerguelen (*Eaton* !).

Hariot is certainly right in separating this plant from the last. De Toni places it with a query under *Rhodymenia*, but Hariot distinctly states that the cystocarp is that of *Callophyllis*.

CALLYMENIA ANTARCTICA, *Hariot, Prem. Expéd. Ant. Franç., Algæ*, p. 7; *Gain, Deux. Expéd. Ant. Franç., Algæ*, p. 60.

W. Falklands; West Point Island, *Hennis*.

DISTRIB. Graham Land, Falkland Islands.

C. antarctica is the only species of the genus known from the Antarctic or Subantarctic regions. Hariot's description is somewhat brief, but, as the Falkland Islands specimens agree well with it, there seems no reason to regard them as distinct. The plant was found by both the French expeditions, and on each occasion off Graham Land; the present record, therefore, gives it extension of range.

The alga is certainly a *Callymenia*, ripe cystocarps showing the usual structure of the genus. The fronds in the present gathering are ovate, tapering gradually to the base or more or less truncate, and the tufted habit noted by Hariot is well marked.

CATENELLA OPUNTIA, *Grev. Alg. Brit.* p. 163, tab. 17.

W. Falklands; Roy Cove, *Vallentin*.

DISTRIB. N. Atlantic, New Zealand, Chile, Fuegia.

C. Opuntia is probably more widely spread than hitherto supposed. It is an addition to the Falkland Islands list, but was recorded by Hariot from Fuegia.

ACANTHOCOCCUS ANTARCTICUS, *Hook. f. et Harv. in Lond. Journ. Bot.* iv. (1845) p. 261; *Fl. Ant.* ii. p. 477, tab. 181.

E. Falklands, *Hohenacker*; Port William, Cape Pembroke, Berkeley Sound, *Hooker*; Port Stanley, *Abbott*. W. Falklands; West Point Island, *Vallentin, Hennis*; Roy Cove, *Vallentin*.

DISTRIB. Fuegia, Falkland Islands, Kerguelen.

A. SPINULIGER, *J. Ag. in Act. Holm. Öfvers.* 1849, p. 87. *Gracilaria obtusiangula*, Hook. f. et Harv. in Lond. Journ. Bot. iv. (1845) p. 260.

E. Falklands, *Gaudichaud, Freycinet*; St. Salvador Bay, *Hooker*. W. Falklands; West Point Island, *Vallentin, Hennis*.

DISTRIB. Fuegia, Falkland Islands, S. Orkneys.

GRACILARIA AGGREGATA, *Hook. f. et Harv. in Lond. Journ. Bot.* iv. (1845) p. 261; *Fl. Ant.* ii. p. 478.

E. Falklands; Berkeley Sound, *Hooker*. W. Falklands; West Point Island, *Hennis*.

Distrib. Falkland Islands, Graham Land (?).

G. aggregata was described by Hooker & Harvey in 1845 from specimens collected in Berkeley Sound. The material was sterile and the generic position of the genus was marked with a query. In 1889 Hariot, on the evidence of a specimen from the Hooker collection, reduced the plant to a synonym of *Ahnfeltia plicata*. His conclusions were incorporated in De Toni's 'Sylloge,' and the name has disappeared from the Antarctic lists.

Hariot's specimen, however, was evidently wrongly named, since the type-material in Hooker's herbarium is quite distinct from *Ahnfeltia*, being stouter, springing from a large basal disk, and possessing internally larger cells. The plant has, as Hooker states, all the appearance of a *Gracilaria*. Fortunately it is now possible to confirm this point, as in Miss Hennis's collection there are a few specimens of the same species, some of which bear the well-marked *Gracilaria* cystocarps. Hooker's specimens are slightly stouter than those collected by Miss Hennis, but this is probably due to their being somewhat old.

Though *G. aggregata* would appear to be a rather uncommon plant, it is possible that it may have been collected in South America and recorded under *Gymnogongrus* spp. or other name. It resembles in habit the short, much branched forms of *G. confervoides*, and it is not improbable that the Antarctic record of the latter species (Hariot, '07) refers in reality to *G. aggregata*. From *G. confervoides* the present plant differs in its large scutate base, small medullary cells, and apparently also in its consistently shorter and more branched habit.

Rhodymenia palmata, *Grev. Alg. Brit.* p. 93 ; *Hook. f. et Harv. in Fl. Ant.* ii. p. 475.

E. Falklands ; Berkeley Sound, Port William, *Hooker* ; Port Stanley, *Cunningham*. W. Falklands ; West Point Island, *Vallentin*.

Distrib. N. Atlantic. N. Pacific (Alaska–N. California, Japan). Fuegia, Falkland Islands, S. Georgia, Kerguelen.

Hooker remarks :—"The Dulse so commonly eaten on the coasts of Scotland is not an unfrequent seaweed on the shores of the Falkland Islands, where it was quickly recognized by some of the north-country seamen of the 'Erebus' and 'Terror.'"

It may be remarked here that the record of *R. palmata*, var. *sobolifera* (=*R. sobolifera*, Hook. f. et Harv., *non* Grev.), in 'Flora Antarctica' is incorrect, all the specimens representing *Callophyllis fastigiata* ; also that the 'Challenger' *Callymenia dentata* records from Kerguelen should be deleted, the specimens being referable to *R. palmata*.

R. flabellifolia, *Mont. Voy.* '*Bonite*,' p. 105; *Hariot, Miss. Cap Horn*, p. 77. *R. palmetta*, Hook. f. et Harv. in Fl. Ant. ii. p. 475 (*non* Grev.).

Falklands, *Gaudichaud*.

Distrib. Peru, Chile, Fuegia.

The record of this rests on Gaudichaud's *R. palmetta*, which was re-examined by Hariot. The plant is possibly the same as that which I have referred to *Phyllophora cuneifolia*.

Plocamium secundatum, *Kütz. Tab. Phyc.* xvi. p. 15, tab. 42. *P. coccineum*, Lyngb.; Hook. f. et Harv. in Fl. Ant. ii. p. 474 (partim).

E. Falklands; Berkeley Sound, Cape Pembroke, *Hooker*; Stanley Harbour, *Vallentin*. W. Falklands; King George's Sound, Roy Cove, West Point Island, *Vallentin*; West Point Island, *Hennis*.

Distrib. Fuegia, Falkland Islands, S. Orkneys, Kerguelen (teste *Askenasy*).

All the Falkland Islands material that I have seen belongs to the plant named by Kützing *P. secundatum*. Hariot followed Hooker, referring his Fuegian material to *P. coccineum*; but it appears to me that *P. secundatum* is a valid species.

Nitophyllum lividum, *Hook. f. et Harv. in Lond. Journ. Bot.* iv. (1845) p. 253; *Fl. Ant.* ii. p. 472, tab. 179.

E. Falklands; Port William, Berkeley Sound, *Hooker*; Port Stanley, *Abbott*. W. Falklands; Roy Cove, *Vallentin*.

Distrib. Fuegia, Falkland Islands, Kerguelen (?).

Nitophylla are abundant in the Falkland Islands, but, as in the north temperate regions, are difficult to understand correctly except from a good series of specimens or when studied in their natural surroundings. *N. lividum* is one of the rarer species; a single specimen from Roy Cove, which agrees with the types at Kew except for the colour being more purple and less livid, is here referred to it. Though young, the plant bears antheridial sori: these are densely scattered over the entire surface of the frond as minute, slightly elongated spots. The nerves are well developed at the base, but the lamina is veinless. The species has been recorded from Kerguelen both by Dickie and Askenasy. Dickie's Kew specimens are, however, doubtful, differing from the type in colour and outline of fronds.

N. Grayanum, *J. Ag. Bidr. Florid. Syst.* p. 48.

Falkland Islands, *Abbott*; in herb. Gray, teste *Agardh*.

Distrib. Falkland Islands.

Professor Nordstedt was kind enough to send a tracing of the type of *N. Grayanum*, which was based on a specimen from the Falklands in herb. Gray. The plant, somewhat torn and imperfect, consists of an oblong-lanceolate frond bearing tetraspores over the entire surface. It differs from *N. Smithii* in the absence of nerves, and is probably closely related to *N. laciniatum*.

NITOPHYLLUM MULTINERVE, *Hook. f. et Harv. in Lond. Journ. Bot.* iv. (1845) p. 255 ; *Fl. Ant.* ii. p. 473.

E. Falklands ; Berkeley Sound, *Hooker* ; Port Stanley, *Abbott.* W. Falklands ; West Point Island, *Vallentin*, *Hennis.*

DISTRIB. Fuegia, Falkland Islands, Kerguelen, New Zealand, Auckland, Tasmania.

Several fine specimens of this beautiful and well-marked species were forwarded. It is fairly frequent in the Magellan region, and the specimens from New Zealand and Tasmania, though differing slightly, appear to be referable to the same species.

N. SMITHII, *Hook. f. et Harv. in Lond. Journ. Bot.* iv. (1845) p. 256 ; *Fl. Ant.* ii. p. 473, tab. 178.

E. Falklands ; Cape Pembroke, *Hooker.*

DISTRIB. Falkland Islands.

One of the less satisfactory of Hooker & Harvey's species, as the original gathering is mixed and the figure in 'Flora Antarctica' is a composite one. The central figure must, I think, be regarded as the type, and the original of this is at Kew ; the smaller lateral fronds, the "veinless varieties," evidently represent other specimens. The type is a strongly veined, very marked plant, and I have seen no other specimens which I could with certainty refer to it. The other 1842 gatherings named *N. Smithii* in the Kew collections are referable to *N. laciniatum.*

N. LACINIATUM, *Hook. f. et Harv. in Lond. Journ. Bot.* iv. (1845) p. 256. *N. Bonnemaisoni*, var. *laciniatum*, Hook. et Harv. in Fl. Ant. ii. p. 474.

E. Falklands ; Berkeley Sound, *Hooker* ; Port Stanley, *Abbott*, *Vallentin.* W. Falklands ; West Point Island, *Vallentin*, *Hennis.*

DISTRIB. Fuegia, Falkland Islands, Kerguelen (?).

Judging from Hooker's specimens, the typical form of *N. laciniatum* has somewhat the outline of *Callophyllis laciniata*, but it varies from the blunt lobes of *N. Bonnemaisoni* to the deeply cleft, almost pinnately branched segments of *N. laceratum.* It appears to be not infrequent in the Magellan region, and is very closely allied to the last-named, from which in the sterile state it is almost impossible to distinguish it. The tetraspores are, however, scattered over the whole frond, and not confined to the margins or lateral proliferations.

Several large specimens in Mrs. Vallentin's algæ I have referred somewhat doubtfully to this species.

? N. DURVILLEI, *J. Ag. Sp.* ii. p. 666. *Delesseria platycarpa*, Hook. f. et Harv. in Fl. Ant. ii. p. 471 (*non* Lamour.).

E. Falklands ; Port William, Cape Pembroke, *Hooker.*

DISTRIB. Chile.

The plant recorded as *D. platycarpa* in 'Flora Antarctica' is certainly not the same as *D. platycarpa*, Lamour. (=*Botryoglossum platycarpum*, Kütz.), from the Cape. It is apparently a rare or local species, as it has not been obtained since Hooker's time, but his record remains. The original specimens have tetraspores in the main fronds as in *Nitophyllum*, and not in special leaflets as in *Botryoglossum*, and correspond fairly closely with Bory's figure of *N. Durvillei* ('28, tab. 19). This alga was collected at Concepcion, Chile, and is little known; hence, though the Falkland Island plant is closely allied to it, it appears best not to link it too definitely with that species till further data on the distribution and variation are available. It is therefore listed with a query.

Platyclinia Crozieri, *J. Ag. Sp.* iii. 3, p. 107. *Nitophyllum Crozieri*, Hook. f. et Harv. in Fl. Ant. ii. p. 172, tab. 177.

W. Falklands; West Point Island, *Vallentin.*

Distrib. Fuegia, Falkland Islands.

J. Agardh, during the last years of his life, transferred this well-marked and very fine species, together with two others, to a separate genus, *Platyclinia*, the necessity of which was open to question. In addition to its laminate frond, *P. Crozieri* may be distinguished from other Falkland Islands Nitophylleæ by the tendency of the cells to be collected together into groups of 2 or 4 as in *Porphyra.*

Delesseria phyllophora, *J. Ag. Bidr. Florid. Syst.* p. 55. *D. crassinervia*, Hook. f. et Harv. in Fl. Ant. ii. p. 471, partim (*non* Montagne).

E. Falklands; Berkeley Sound, *Hooker.*

Distrib. Falkland Islands.

The nomenclature of the Delesserieæ is much complicated, owing to the liberal views as to species held by the older writers and by the poorness of much of the original material. *D. phyllophora* was one of the species separated from *D. crassinervia*, Hook. f. & Harv. (*non* Mont.), by J. Agardh. It was founded on a Falkland Island specimen collected by Hooker in 1842, and two or three plants apparently referable to it exist at Kew. The Kerguelen plant recorded by Hooker and Harvey is probably distinct from *D. phyllophora*, which, so far as I can judge, has not been met with elsewhere nor since that date.

Paraglossum lancifolium, *J. Ag. Sp.* iii. 3, p. 217. *Delesseria sanguinea*, var. *lancifolia*, Hook. f. et Harv. in Fl. Ant. ii. p. 470.

W. Falklands; West Point Island, *Vallentin, Hennis.*

Distrib. Fuegia, Falkland Islands.

It is with some hesitation that this species is added to the Falkland Islands list. Agardh quoted *D. sanguinea*, var. *lancifolia*, Hook. f. et Harv., as a

doubtful synonym of his species *D. lancifolia* from the same locality. This has generally been assumed to be correct, and the Hooker specimens at Kew are found to agree fairly well with Agardh's description. The single and very fine specimen collected by Mrs. Vallentin is useful in providing the hitherto-unknown cystocarps. These are borne in minute proliferations, which arise over the entire surface of the frond. The cystocarps occur singly or in twos in the proliferations.

D. lancifolia, var. *minor*, Laing (Trans. N.Z. Instit. xxix. p. 450), from Macquarie, is probably a distinct species.

PARAGLOSSUM EPIGLOSSUM, *J. Ag. Sp.* iii. 3, p. 217. *Delesseria crassinervia*, Hook. f. et Harv. in Fl. Ant. ii. p. 471, partim (*non* Montagne).

E. Falklands, *Hooker.*

DISTRIB. Falkland Islands, Fuegia, Kerguelen (?).

D. crassinervia covered a number of species. The true plant, known only with certainty from New Zealand, Campbell and Auckland Islands, appears to be a *Hypoglossum*, and *D. Montagneana*, which was separated from it, has been shown by Laing also to be a composite species. *P. epiglossum* is, so far as known, confined to the Cape Horn district.

PTERIDIUM BERTRANDII, *Cotton*, sp. nov. (Pl. 8.)

Delesseria Davisii, Dickie, in Journ. Linn. Soc., Bot. xv. (1876) pp. 45 et 200, *non* Hook. f. et Harv.

Frondes amplæ, cæspitosæ, dense dichotomæ, 15–20 cm. longæ. Rami ramulique complanati, costati, alati, ligulati vel ligulato-cuneati, 5–8 mm. lati, supra sinus plerumque oblique excisi, venis lateralibus omnino deficientibus, margine undulata fere integra. Cystocarpia non spinosa, in segmentis terminalibus sparsa, costæ imposita. Tetrasporangia utroque latere et supra costæ ramulorum disposita, sori vix discreti.

W. Falklands ; West Point Island, *Vallentin.*

DISTRIB. Kerguelen (*Moseley & Eaton*), Fuegia (Port Famine, *Hooker*). W. Falklands (?).

The present species is apparently frequent in Kerguelen, and it occurs also in the Magellan district. In the tetrasporic state it is very well marked, but in the sterile or even cystocarp condition it is not always easy to identify with certainty. For this reason the Falkland Island record has had to be marked with a query ; but, as the plant occurs at Port Famine, there is no danger of a geographical error. Abundant material from Kerguelen exists in herbaria, and, being hitherto undescribed, it was advisable to deal with the plant even though its discovery on the Falklands themselves had not been positively certified. The type-material is that collected by Eaton during the 'Transit of Venus' Expedition (see Plate 8).

The cuneate segments give the plant a very marked appearance, though it

is probable that under certain conditions or in certain stages of growth the fronds of other species possess a similar outline. The cystocarps being situated on the nerves, and the tetraspores in sporangial plants in lines on either side, locate it as a *Pteridium*, where it is fairly distinct from other species. From *Pteridium proliferum*, A. & E. S. Gepp, which was collected at the Orkneys by the 'Scotia,' it differs in the broader segments and disposition of the tetraspores.

The species is named after the late Mr. W. Wickham Bertrand, Mrs. Vallentin's father, who took the greatest interest in the flora of the islands, and especially in the present collection of Cryptogams.

Glossopteris Lyallii, *J. Ag. Sp.* iii. 3, p. 197. *Delesseria Lyallii*, Hook. f. et Harv. in Lond. Journ. Bot. iv. (1845) p. 252; Fl. Ant. ii. p. 471, tab. 176 (*non* Harv. Alg. Austral. exsicc., *nec* Phyc. Austr.).

E. Falklands; Cape Pembroke, Port William, *Hooker*; Port Stanley, *Abbott*. W. Falklands; Roy Cove, West Point Island, Rapid Point, *Vallentin*; West Point Island, *Hennis*.

Distrib. Fuegia, Falkland Islands, Kerguelen.

Formerly thought to extend to Australia, but the specimens from that continent were shown by Agardh to be a distinct species (*D. simulans*).

Schizoneura quercifolia, *J. Ag. Sp.* iii. 3, p. 168. *Delesseria quercifolia*, Bory, Voy. 'Coquille,' p. 186, tab. 18. fig. 1; Hook. f. et Harv. in Fl. Ant. ii. p. 471.

E. Falklands; St. Salvador Bay, Berkeley Sound, Port William, Cape Pembroke, *Hooker*; Port Stanley, *Abbott*. W. Falklands; West Point Island, Roy Cove, Dunmose Head, *Vallentin*.

Distrib. Fuegia, Falkland Islands, Graham Land (teste *Gain*), S. Georgia (teste *Reinsch*), Kerguelen (broad form only), Coulman Island (teste *Gepp*).

It is possible that more than one species is at present included under this name, as there are a few specimens both in the Hooker and Vallentin collections which have fronds markedly broader and of a deeper colour than the ordinary form.

S. Davisii, *J. Ag. Sp.* iii. 3, p. 168. *Delesseria Davisii*, Hook. f. et Harv. in Lond. Journ. Bot. iv. (1845) p. 252; Fl. Ant. ii. p. 470, tab. 175.

E. Falklands; Berkeley Sound, *Hooker*.

Distrib. Fuegia! Falkland Islands (?).

There are four of Hooker's specimens at Kew, three precisely similar from Cape Horn agreeing with the figure in 'Flora Antarctica,' and a fourth, apparently different, from Berkeley Sound. Its claim to occur in the Falklands is therefore doubtful. Dickie's Kerguelen record is certainly incorrect,

the speciments both at Kew and the British Museum being quite distinct and approaching rather *S. dichotoma.*

PTILONIA MAGELLANICA, *J. Ag. Sp.* ii. p. 744. *Plocamium? magellanicum*, Hook. f. et Harv. in Lond. Journ. Bot. iv. (1845) p. 257; Fl. Ant. ii. p. 474.

Falklands; general, many collectors.

DISTRIB. Fuegia, Falkland Islands, Kerguelen.

The fronds of this plant are apt to be mistaken for a broad form of *Plocamium.* It is very frequent in the Cape Horn region and in the Falklands, but elsewhere has only been found at Kerguelen.

CHONDRIA sp. *Laurencia pinnatifida*, var. *angustata*, Hook. f. et Harv. in Fl. Ant. ii. p. 484.

E. Falklands; Berkeley Sound, Cape Pembroke, *Hooker.* W. Falklands; Roy Cove, West Point Island, *Vallentin.*

DISTRIB. S. Chile, Falkland Islands.

Although the genus has never been recorded from the Magellan region, a species of *Chondria* certainly occurs in the Falklands. Mrs. Vallentin brought home several specimens, and the Kew collections show that Hooker collected the same plant in 1842, and referred it in 'Flora Antarctica' to *Laurencia pinnatifida*, var. *angustata.* This species has since been recorded by other authors, and it continues to find a place in antarctic lists. All the specimens I have seen, however, should be referred to *Chondria*, and it is very doubtful if *Laurencia* occurs at all in that region.

Species of the present genus possess few distinctive characters, and are, especially in the dried state, difficult to classify. The Falkland Island plant is cæspitose, and approaches *C. atropurpurea*, Harv., from the North Pacific, in habit, but, until its range of variation and its reproductive organs are more perfectly known, it is impossible to decide on its specific identity.

LOPHURELLA COMOSA, *Falk. Rhodomelaceen*, p. 158, t. 19. fig. 31. *Rhodomela comosa*, Hook. f. & Harv. in Lond. Journ. Bot. iv. (1845) p. 263; Fl. Ant. ii. p. 482, tab. 185.

E. Falklands; Berkeley Sound, St. Salvador Bay, *Hooker.* W. Falklands; Shallow Bay, *Vallentin*; West Point Island, *Hennis.*

DISTRIB. Falkland Islands.

The dense fibrillose shoots, which give it somewhat the appearance of *Polysiphonia fibrillosa*, distinguish this from allied species of the genus.

L. HOOKERIANA, *Falk. Rhodomelaceen*, p. 158. *Rhodomela Hookeriana*, J. Ag. Sp. ii. p. 880. *Lophura tenuis*, Kütz. Diagn. u. Bemerk. no. 68,

p. 18; De Toni, Syll. Alg. iv. p. 1133. *Rhodomela Gaimardi*, Hook. f. et Harv. in Fl. Ant. ii. p. 481, tab. 184 (*non* Ag., *nec* Mont.).

E. Falklands; Berkeley Sound, *Hooker*; Port Stanley, *Hohenacker*, *Abbott*. W. Falklands; West Point Island, Roy Cove, *Vallentin*.

Distrib. Fuegia, Falkland Islands, Kerguelen.

This is the plant referred to *R. Gaimardi*, Gaud., by Hooker & Harvey in 'Flora Antarctica.' J. Agardh refused this identification and described Hooker's plant as a new species—*R. Hookeriana*. It is not certain whether Agardh was justified in this, as the species of the genus are well known to vary at different seasons of the year. The original material also of *R. Gaimardi* requires to be re-examined.

With regard to the synonym *L. tenuis*, my thanks are due to Madame Weber van Bosse for allowing me to examine Kützing's specimen. Its identity is clear enough, but a difficulty arose as to nomenclature, since the exact date of publication was not easy to ascertain, and copies of Kützing's paper are exceedingly scarce. I am indebted to Mr. Gepp for drawing my attention to a reference in Hedwigia (xxxii. p. 333), which showed that the paper was published in the 'Programme der Realschule zu Nordhausen' in 1863, and to Madame Webèr, who at the same moment confirmed the date by means of a separate copy in the library of the Botanical Society of Holland. As Agardh's name, which was published in the same year, is well known and has been generally accepted, and, as Kützing's has always been uncertain, the former should unquestionably be adopted.

L.? Gaimardi, *De Toni, Syll. Alg.* iv. p. 858. *Rhodomela Gaimardi*, Ag. Sp. i. p. 380 (*non* Mont., *nec* Hook. f. et Harv.).

Falkland Islands, *Gaudichaud*.

Distrib. Falkland Islands.

See note under *L. Hookeriana*.

L. patula, *De Toni, Syll. Alg.* iv. p. 859. *Rhodomela patula*, Hook. f. et Harv. in Lond. Journ. Bot. iv. (1845) p. 264; Fl. Ant. ii. p. 481, tab. 183. fig. 4.

E. Falklands; Port William, Berkeley Sound, *Hooker*.

Distrib. Fuegia, Falkland Islands, Kerguelen.

Polysiphonia anisogona, *Hook. f. et Harv. in Lond. Journ. Bot.* iv. (1845) p. 265; *Fl. Ant.* ii. p. 478, tab. 182. fig. 2.

E. Falklands; Berkeley Sound, *Hooker*. W. Falklands; Roy Cove, *Vallentin*; West Point Island, *Vallentin*, *Hennis*.

Distrib. Fuegia, Falkland Islands, S. Georgia, Kerguelen.

Apparently common and very variable. Mrs. Vallentin's specimens show that the species attains a considerable size, and that Hooker's type-specimens

are merely fragments. The plant bears a strong resemblance to *P. urceolata* of the Northern Hemisphere, especially in its elongated growth and slender, persistently uncorticated branches, which, however, consist of 12–14 instead of 4 tubes.

An examination of Hooker's specimen of *P. atro-rubescens* shows that the Falkland Islands record of this species is an error, the plant being clearly a small example of the present species.

Polysiphonia fusco-rubescens, *Hook. f. et Harv. in Fl. Ant.* ii. p. 478, tab. 182. fig. 1.

E. Falklands, *Sulivan.*

Distrib. Falkland Islands.

A rare and little-known plant, and not recorded since the time of Hooker.

Pteronia pectinata, *Schmitz in Engl. & Prantl, Natürl. Pflanzenfam.* Teil i. Abt. 2, p. 452. *Dasya pectinata*, Hook. f. et Harv. in Fl. Ant. ii. p. 482; Harv. Nereis Austral. p. 67, tab. 27.

E. Falklands, *Hooker.*

Distrib. Fuegia, Falkland Islands, S. Georgia (teste *Reinsch*), S. Orkneys.

See notes by Mr. & Mrs. Gepp ('12, p. 81).

Herposiphonia Sulivanæ, *Falk. Rhodomelaceen*, p. 315. *Polysiphonia Sulivanæ*, Hook. f. et Harv. in Fl. Ant. ii. p. 479, tab. 182. fig. 4.

E. Falklands, *Hooker.* W. Falklands; West Point Island, *Vallentin.*

Distrib. Falkland Islands.

Bostrychia Hookeri, *Harv. in Lond. Journ. Bot.* iv. (1845) p. 269. *Stictosiphonia Hookeri*, Harv. in Hook. f. Fl. Ant. ii. p. 483, tab. 186. fig. 2.

E. Falklands; Port William, Berkeley Sound, *Hooker*; Port Stanley, *Abbott.* W. Falklands; Roy Cove, *Vallentin.*

Distrib. Fuegia, Falkland Islands.

Several fine tetrasporic specimens were collected by Mrs. Vallentin on rocks near high-water mark in the neighbourhood of fresh-water. The plant sent out by Hohenacker under this name is doubtful.

B. vaga, *Hook. f. et Harv. in Lond. Journ. Bot.* iv. (1845) p. 270. *Stictosiphonia vaga*, Hook. f. et Harv. in Fl. Ant. ii. p. 484, tab. 186. fig. 1.

E. Falklands; Port Stanley, *Hohenacker.*

Distrib. Kerguelen, Falkland Islands (?).

A small species described by Hooker & Harvey from Kerguelen and distributed by Hohenacker (No. 291) from Port Stanley. The Falkland

Islands specimen is apparently correctly named, but it may be noted that his Chiloe specimen is not *Bostrychia* but a *Gelidium*.

Bostrychia intricata, *Mont. in C. Gay, Fl. Chilena*, viii. p. 309.

Falkland Islands, *D'Urville*.

Distrib. Falkland Islands, Chile.

Hariot notes that this species is allied to *B. Hookeri*, and it is possible that the two are synonymous.

Heterosiphonia Berkeleyi, *Mont. Prodr. Phyc. Antarct.* p. 4. *Polysiphonia Davisii*, Hook. f. et Harv. in Lond. Journ. Bot. iv. (1845) p. 267; Fl. Ant. ii. p. 481.

Falkland Islands, general, *Hooker*, *Abbott*, *Vallentin*, *Hennis*.

Distrib. Fuegia, Falkland Islands, Kerguelen, Auckland Island.

Var. squarrosa (*Kütz.*), *Cotton*, comb. nov. *Polysiphonia squarrosa*, Kütz. Spec. p. 822; De Toni, Syll. Alg. iv. p. 939, sub *P. atro-rubescens*.

Distrib. Probably same as type.

The original specimen of *P. squarrosa*, Kützing, which Madame Weber was kind enough to lend me, shows that it is a *Heterosiphonia*, being the not uncommon squarrosely-branched plant which is usually regarded as a form of *H. Berkeleyi*. I have little doubt that this view is correct, as several other sublittoral plants assume a very similar form under certain conditions. In reducing the plant to varietal rank Kützing's name is retained, though it should be pointed out that the alga is in no way related to *Heterosiphonia squarrosa* (Hook. f. & Harv.), De Toni, from New Zealand.

H. polyzonioides, *J. Ag. Till Alg. Syst.* xi. (1890) p. 73.

E. Falklands; Port William, coll. ——?

Distrib. Falkland Islands.

This species (overlooked by Gain in his useful tables) was described by Agardh during his later years. The description agrees so well with *H. Berkeleyi*, var. *squarrosa*, that examination of the type will probably show that *H. polyzonioides* is identical with this plant.

Bornetia? antarctica, *De Toni, Syll. Alg.* iv. p. 1297. *Griffithsia antarctica*, Hook. f. et Harv. in Fl. Ant. ii. p. 488.

E. Falklands; Port William, Berkeley Sound, *Hooker*; Port Louis, *Moseley*. W. Falklands; West Point Island, *Vallentin*, *Hennis*. Dunmose Head, *Vallentin*.

Distrib. Fuegia, Falkland Islands; (Southern Australia?).

It is more than doubtful if the Australian plant belongs to this species.

Callithamnion Montagnei, *Hook. f. Fl. Ant.* ii. p. 490, tab. 188. fig. 2.

E. Falklands; Berkeley Sound, *Hooker.* W. Falklands; Roy Cove, West Point Island, *Vallentin, Hennis.*

Distrib. Fuegia, Falkland Islands.

The difference between this and the following species is not clear. The Falkland Islands Callithamnieæ are as yet very imperfectly known, and several undescribed species probably exist. Three or four plants collected by Mrs. Vallentin, also some unnamed specimens in the Kew Herbarium, are referable to *Callithamnion* or an allied genus, but being sterile cannot be determined.

C. Gaudichaudii, *Ag. Sp.* ii. p. 173.

E. Falklands, *Gaudichaud.*

Distrib. Fuegia and Falkland Islands.

C. leptocladum, *Mont. Voy. Pôle Sud,* p. 91.

E. Falklands, *Gaudichaud.*

Distrib. Fuegia and Falkland Islands.

A little-known plant.

Plumaria Harveyi, *Schmitz, in Nuovo Not.* v. (1894) p. 7. *Ptilota Harveyi,* Hook. f. in Lond. Journ. Bot. iv. (1845) p. 271; Hook. f. et Harv. in Fl. Ant. ii. p. 487, tab. 187.

E. Falklands; Cape Pembroke, *Hooker.* W. Falklands; West Point Island, *Vallentin, Hennis*; Roy Cove and Shallow Bay, common, *Vallentin.*

Distrib. Fuegia, Falkland Islands.

Ballia callitricha, *Mont. in Dict. univ.* p. 442, tab. 2. *Ballia Bruonis,* Harv. in Lond. Journ. Bot. ii. (1843) p. 191, tab. 9; Hook. f. et Harv. in Fl. Ant. ii. p. 488.

Falkland Islands; general, all collectors.

Distrib. Fuegia, Falklands, S. Georgia, Marion Island, Crozets, Kerguelen, Southern Australia, New Zealand, Auckland Island.

Abundant in the Falkland Islands and widely distributed in the sub-antarctic.

B. scoparia, *Harv. Phyc. Austr.* tab. 168. *Callithamnion scoparium,* Hook. f. et Harv. in Lond. Journ. Bot. iv. (1845) p. 273; Fl. Ant. ii. p. 490, tab. 189. fig. 3.

E. Falklands; Berkeley Sound, *Hooker*; Port Stanley, *Abbott.* W. Falklands; Fox Bay, *Vallentin.*

Distrib. S. Chile, Fuegia, Falklands, Southern Australia, New Zealand, Auckland Island.

A much less common species, and with a more restricted distribution.

Antithamnion flaccidum, *De Toni, Syll. Alg.* iv. p. 1414. *Callithamnion flaccidum*, Hook. f. et Harv. in Lond. Journ. Bot. iv. (1845) p. 273; Fl. Ant. ii. p. 490, tab. 188. fig. 1.

W. Falklands; West Point Island, Roy Cove, *Vallentin.*

Distrib. Fuegia, Falkland Islands; (New Zealand ?).

New to the Falkland Islands. The irregular branching noted by Hooker & Harvey is shown to a remarkable extent, but there can be no doubt that these authors were correct in referring all plants to one species. The New Zealand plant, known under the name of *A. flaccidum*, will probably prove to be a distinct species.

Ceramium rubrum, *Ag. Sp.* ii. p. 146; *Hook. f. et Harv. in Fl. Ant.* ii. p. 488.

Falkland Islands, general, all collectors.

Distrib. Cosmopolitan.

Found abundantly in the W. Falklands by Mrs. Vallentin, and represented in a variety of forms in all collections.

C. diaphanum, *Roth, Cat. Bot.* iii. p. 154; *Hook. f. et Harv. in Fl. Ant.* ii. p. 488.

E. Falklands, *Hooker.* W. Falklands; Shallow Bay, *Vallentin.*

Distrib. Probably cosmopolitan.

Dr. H. E. Petersen of Copenhagen has been kind enough to examine Mrs. Vallentin's diaphanous *Ceramia*, and he is of opinion that, with the exception af one specimen, they should all be referred to *C. diaphanum.*

C. strictum, *Grev. et Harv. in Harv. Phyc. Brit.* p. xi, tab. 334.

E. Falklands (teste *Agardh*). W. Falklands; Shallow Bay, *Vallentin.*

Distrib. Probably cosmopolitan.

Rhodochorton membranaceum, *Magnus, Bot. Erg. Nordseef.* p. 67, tab. 2. figs. 7–15; *Kuckuck, Beitr.* ii. pp. 13–24, figs. 1–7.

W. Falklands; West Point Island, *Hennis*, Dunnose Head, *Vallentin.*

Distrib. N. Atlantic (Europe and America).

The first record of the genus for the islands. The present species is endozoic, and occurred in the Hydroid zoophyte, *Sertularella polyzonias* (Linn.), a species which is almost cosmopolitan in its distribution. At first it seemed as though the alga differed from the well-known Atlantic form in

the very short sporangial stalk, but Kuckuck in his detailed account shows that both long and short stalked forms occur, and sometimes on the same individual.

Hildenbrandtia Le-Cannelieri, *Hariot, in Journ. de Bot.* i. (1887) p. 74; *Algues Cap Horn*, p. 81, pl. 6. figs. 3 & 4.

W. Falklands; Roy Cove, *Vallentin.*

Distrib. Fuegia, Falklands, Graham Land.

This remarkable plant, first described by Hariot in 1887, appears to be frequent in brackish localities in the Cape Horn region. Mrs. Vallentin states that it was found "growing in abundance at high-water mark up Roy Cove Creek, where the water is brackish," and Hariot comments on its widespread distribution in Fuegia.

Corallina officinalis, *Linn. Faun. Suec.* ed. 2, p. 528, no. 2234.

E. Falklands, *Darwin.* W. Falklands; St. George's Sound, Roy Cove, *Vallentin.*

Distrib. General in N. and S. temperate seas, also in the Arctic Sea and tropical S. America.

Not a single species of *Corallina* is listed in 'Flora Antarctica,' though it is now known that several species flourish in the Magellan region, and there is a specimen collected by Darwin in the Hooker herbarium. Mrs. Vallentin's gatherings consisted of the short high-water form known as var. *mediterranea*, and she notes that the plant is scarce.

C. pilulifera, *Post. et Rupr. Illustr.* p. 20, tab. 40. fig. 101; *Yendo, Cor. Veræ Japan*, p. 30, tab. 3. figs. 14–16 (1902).

W. Falklands; Fox Bay, West Point Beach, *Vallentin.*

Distrib. Pacific coasts of N. and S. America, Japan, Fuegia, New Zealand.

For the addition of this species to the Magellan region list I am indebted to Prof. K. Yendo, who, being well acquainted with the plant in the North Pacific, readily recognized the Falkland Island specimens. *C. pilulifera* is much confused in herbaria, and is found under *C. squamata*, *C. officinalis*, and *C. armata.* For its distinctive features, see Yendo, *l. c.*

Amphiroa charoides, *Lamx. Pol. flex.* p. 310. *A. cyathifera*, Hariot, Cape Horn, p. 86 (*non* Lamx.).

Falkland Islands, *Freycinet.*

Distrib. Australia (southern shores only?).

Professor Yendo, who was kind enough to look up the 'Uranie' specimen during his visit to Paris, writes that it should be referred to *A. charoides*

rather than *A. cyathifera.* He adds that Harvey's exsicc. no. 462 is quite distinct from the true *A. charoides.*

AMPHIROA sp.

West Falklands; Roy Cove, West Point Island, *Vallentin.*

A species very distinct from the last was found by Mrs. Vallentin in two localities. Both gatherings unfortunately are sterile, but it is allied to the North Pacific *A. tuberculosa*, Aresch. As it is clearly an addition to the flora, and being the second record only of the genus, it appears to be worthy of notice.

MELOBESIEÆ.

By Mme. PAUL LEMOINE.

Les Mélobésiées recueillies aux Iles Falkland en 1910 par Mrs. Vallentin constituent une petite collection fort intéressante; j'y ai reconnu sept espèces, dont une espèce est nouvelle ; ce sont :—

Lithothamnium antarcticum (Hook. f. et Harv.), Heyd.
„ *Patena* (Hook. f. et Harv.), Fosl.
„ *Schmitzii* (Hariot), Heyd.
„ *neglectum*, Foslie (= *L. variabile*, Fosl.).
„ *falklandicum*, Foslie.
Pseudolithophyllum discoideum (Fosl.), Lemoine.
Epilithon Vallentinæ, Lemoine, sp. nov.

On connaissait jusqu'ici six espèces de Mélobésiées aux Iles Falkland ; Mrs. Vallentin en a retrouvées cinq. Le *Lithothamnium fuegianum* n'a pas été rencontré par elle ; mais elle a recueilli de plus deux espèces nouvelles pour la région : *Epilithon Vallentinæ*, espèce nouvelle, et *Lithothamnium Patena*, qui paraît être, aux Iles Falkland, à la limite de son aire d'extension.

Comme il n'a encore été recueilli que peu d'espèces et peu d'échantillons des régions subantarctiques j'insisterai spécialement, à propos de la description des échantillons recueillis par Mrs. Vallentin, sur quelques espèces dont je n'avais pas eu connaissance lors de la rédaction de mon précédent mémoire (Lemoine, 1913) sur les algues calcaires des régions antarctiques.

LITHOTHAMNIUM ANTARCTICUM, *Heydr. in Engler's Bot. Jahrb.* xxviii. (1901) p. 544 ; *Lemoine, Rév. Mélob. Ant.* p. 15. *Melobesia verrucata*, var. *antarctica*, Hook. f. et Harv. in Fl. Ant. ii. p. 482.

E. Falklands, *Hooker* ; W. Falklands, *Vallentin.*

DISTRIB. Voir l'espèce suivante.

Cette espèce est représentée par des échantillons, pourvus des deux sortes de conceptacles, ayant poussé sur *Ballia*, *Corallina* et *Codium mucronatum.*

Lithothamnium Patena, *Heydr. in Engler's Bot. Jahrb.* xxviii. (1901) p. 542. *Melobesia Patena*, Hook. f. & Harv. Nereis Austr. p. 111. (Pl. **9**. fig. 1.)

W. Falklands, *Vallentin.*

Distrib. Sud de l'Australie, N. Zélande, Cap de Bonne Espérance, Ile Auckland.

Parmi les échantillons épiphytes dont la plupart appartiennent au *L. antarcticum*, il en existe quelques-uns vivant sur *Ballia*, qu'il faut attribuer au *L. Patena*. La question de l'individualité des trois espèces *L. lichenoides*, *L. antarcticum*, *L. Patena* a été posée par de nombreux auteurs. En dernier lieu Foslie les avait réunies et j'ai rappelé son opinion (1911, p. 130). Mais depuis (1913, p. 17), j'ai pu solutionner en partie la question en montrant les différences très nettes qui permettent de séparer *Lithothamnium antarcticum* et *Lithophyllum lichenoides*. Malgré son aspect si caractéristique l'individualité du *L. Patena* est une question plus difficile à trancher; cette question a déjà été posée par Harvey et Rosanoff, qui se sont demandés si *L. Patena* n'était pas une variété de *L. antarcticum*. En réalité, par l'étude de la structure anatomique, je crois qu'il faut considérer *L. Patena* comme une espèce très voisine de *L. antarcticum* et constituant plutôt une espèce de transition entre *Lithothamnium antarcticum* et *Lithophyllum lichenoides*.

L'aspect des échantillons typiques de *L. Patena* et de *L. antarcticum* est assez différent : *L. Patena* se présente sous l'aspect d'écussons de forme ovale ou orbiculaire, fixés seulement à la base ; la surface est rose et brillante et le contour de la fronde très entier. *L. antarcticum* forme des croûtes toujours plus adhérentes, de couleur grisâtre et terne, le contour est irrégulier ; la forme des thalles est oblongue, plus ou moins allongée.

La structure de chacune des deux espèces est en rapport avec l'adhérence plus ou moins grande de la fronde. Dans le *L. antarcticum* la croûte, généralement adhérente dans sa plus grande partie, est constituée par un hypothalle et un périthalle; mais vers les bords, la croûte est libre et n'est pour ainsi dire constituée que par l'hypothalle (voir 1913, fig. 3). Les croûtes de *L. Patena* sont toujours complètement libres de toute adhérence ; aussi, en coupe, sont-elles constituées en majeure partie par l'hypothalle, se prolongeant à la partie supérieure aussi bien qu'à la partie inférieure par quelques plus petites cellules formant deux périthalles peu développés (Pl. **9**. fig. 1).

Dans le *L. antarcticum* l'hypothalle n'est constitué que par trois à quatre files cellulaires dont les cellules mesurent 13 à 21 μ et ne dépassent pas cette dimension ; dans la *L. Patena,* les cellules de l'hypothalle mesurent 14 à 31 μ, en général 18 à 27 μ. On remarque de plus que les cellules ont une tendance très nette à se disposer en rangées concentriques (Pl. **9**. fig. 1), ce que je n'ai pas observé jusqu'ici dans le *L. antarcticum* ; c'est par ce caractère que *L. Patena* se rapprocherait de *L. lichenoides* dont l'hypothalle est constitué par une série de rangées concentriques en éventails (1911, fig. 60).

Le périthalle est formé de cellules mesurant 10 à 15 μ de longueur et 6 à 8 μ de largeur dans le *L. antarcticum* et de cellules de 5 à 10 μ de longueur dans le *L. Patena*.

Les conceptacles, assez semblables comme forme, ne dépassent pas 700 μ (500 à 700 μ) dans les échantillons typiques de *L. antarcticum* et atteignant jusqu'à 1000 μ (500 à 1000, plus souvent 600 à 850) dans le *L. Patena*. Les conceptacles à sporanges sont bas, en forme de disque, de forme ronde dans *L. antarcticum* et, au contraire, de forme souvent ovale dans *L. Patena* ; les conceptacles à cystocarpes sont coniques dans les deux espèces, mais plus élevés dans *L. Patena*.

Or, si les échantillons de Mrs. Vallentin doivent être rapportés à *L. Patena* par leur structure, il est à remarquer que les conceptacles à sporanges mesurent 450 à 600 μ de diamètre et les conceptacles à cystocarpes 550 à 600 μ ; d'autres conceptacles, de plus petite taille, mais de même forme que les conceptacles à cystocarpes mesurent 350 à 450 μ, ce sont sans doute les conceptacles à anthéridies.

En résumé, les quelques échantillons des Iles Falkland que je rapporte au *L. Patena* ont des conceptacles de dimensions plus faibles que les échantillons typiques, et ils sont beaucoup moins développés que ceux qui proviennent d'Australie. *L. Patena* se trouve, aux Iles Falkland dans une localité extrême de son aire d'extension et les échantillons deviennent intermédiaires entre *L. Patena* et *L. antarcticum*. D'ailleurs des échantillons de l'Herbier Bornet provenant de l'Ile Auckland, c'est à dire également d'une localité située à la limite de son aire d'extension, sont de même mal développés.

L. antarcticum est caractéristique des régions subantarctiques (Terre de Feu, Détroit de Magellan, Cap Horn, Iles Falkland, Orcades, Géorgie, Kerguelen, Ile Auckland) et n'est connu, en dehors de ces régions, qu'en Tasmanie et dans le Sud de l'Australie. *L. Patena* est, au contraire, une espèce australe (Sud de l'Australie, N. Zélande, Cap de Bonne Espérance) et paraît fort rare dans les régions subantarctiques où il n'est connu qu'à l'Ile Auckland (Algæ Muellerianæ) et grâce à Mrs. Vallentin aux Iles Falkland ; dans ces deux dernières localités il s'y trouve en médiocre état de développement. Enfin *Lithophyllum lichenoides* est une espèce des régions tempérées et chaudes surtout de l'hémisphère Nord.

LITHOTHAMNIUM SCHMITZII, *Heydr. Engl. Botan. Jahrb.* xxviii. (1901) p. 541 ; *Lemoine, Rév. Mélob. Ant.* p. 25. *Lithophyllum Schmitzii*, Hariot, in Journ. de Bot. ix. (1895) p. 98. *Lithothamnion magellanicum*, Fosl. New or Crit. Lith. p. 8, fig. 8. *Lithothamnion scutelloides*, Heyd. Exp. Ant. Belge, p. 563.

E. Falklands, Berkeley Sound, *Hooker* ; W. Falklands, *Vallentin*.

DISTRIB. Espèce caractéristique des régions subantarctiques de l'Atlantique, depuis le Détroit de Magellan jusqu'aux Orcades.

L. Schmitzii forme, sur coquilles de *Patella*, des croûtes peu adhérentes pourvues des deux sortes de conceptacles. Les échantillons rappellent beaucoup ceux de la Terre de Feu récoltés par l'Expédition Charcot.

Cette espèce vivait dans la zone littorale ; il en est de même à la Terre de Feu; aux Orcades elle a été signalée dans la région sublittorale.

LITHOTHAMNIUM NEGLECTUM, *Fosl. Die Lith. Deutsch. Südp. Exped.* p. 207; *Lemoine, Rév. Mélob. Ant.* p. 14. *L. Mülleri*, Rosanoff, f. *neglecta*, Fosl. Schwed. expéd. Magellan, p. 69. *L. variabile*, Fosl. *l. c.* (Pl. **9**. fig. 2 ; Pl. **10**. figs. 3–6.)

E. Falklands, *Skottsberg*. W. Falklands, *Vallentin*.

DISTRIB. Ile Kerguelen, Iles Falkland. L'espèce paraît abondante dans ces deux localités. A l'Ile Kerguelen elle est représentée en dehors des échantillons typiques par une variété à feuilles très minces : var. *fragilis* Fosl.

En étudiant les échantillons de Mrs. Vallentin qui correspondent très exactement à la description du *L. variabile* des Iles Falkland, je me suis aperçue que ces échantillons pourraient également rentrer dans l'espèce *L. neglectum* de l'Ile Kerguelen et, après comparaison des caractères de ces deux espèces, il m'a paru préférable de les réunir. En effet l'aspect de ces deux espèces, chacune assez variable, est fréquemment semblable ainsi qu'on pourra s'en convaincre en comparant les photographies données par l'auteur de l'espèce (*L. variabile*, voir Foslie, Antarct. & Subant. Corallin. pl. 1. fig. 7. *L. neglectum*, voir Foslie, Die Lithoth. Deutsch. Südp. Exped. pl. 20. fig. 7).

Il faut noter comme analogies : l'épaisseur des croûtes, les dimensions des cellules, les dimensions des conceptacles à sporanges et à cystocarpes, l'aspect du tissu constitué surtout par l'hypothalle dans les deux espèces. Je ne relève comme différences que le nombre des canaux du toit des conceptacles à sporanges au nombre de 70 à 90 dans l'espèce *L. variabile* et de 50 dans *L. neglectum* ; d'autre part la présence de nouvelles formations cellulaires dans les conceptacles vides de *L. neglectum*, après l'expulsion des sporanges.

Quant au nombre des canaux il faudrait s'assurer si le chiffre de 50 canaux indiqué par Foslie pour *L. neglectum* de Kerguelen n'aurait pas été relevé sur des conceptacles jeunes ; j'ai observé ce même chiffre dans les conceptacles à sporanges jeunes de l'Ile Falkland.

L. neglectum est représentée, dans les récoltes de Mrs. Vallentin, par de nombreux thalles vivant sur coquilles de *Patella* et de *Fissurella* *. Ces thalles sont formés de sortes de petites lamelles de 1 à 4 cm. de diamètre, adhérentes dans leur partie centrale et libres à la périphérie où elles sont recourbés vers le substratum (Pl. **10**. figs. 3 et 4). Les divers échantillons sont assez

* La présence du *L. neglectum* sur les coquilles de Patelles indique qu'il a été recueilli dans la zone littorale.

différents les unes des autres, les lamelles sont très variables de taille; lorsqu'elles sont très petites avec les bords recourbés au-dessus d'elles, l'espèce prend un aspect frisé.

Ces lamelles poussent les unes au-dessus des autres formant, dans certains cas, des thalles de plusieurs centimètres d'épaisseur (Pl. **10.** fig. 5). Le bord de la croûte est généralement épaissi dans cette espèce et très entier.

J'ai également rapporté à cette espèce une croûte très adhérente, couverte de conceptacles à cystocarpes et recouvrant en grande partie une coquille de *Patella* (Pl. **10.** fig. 6); au premier aspect l'échantillon paraît très différent de celui de *L. neglectum*, dont il a cependant la même structure et les mêmes conceptacles; mais on remarque, sur les bords de cette croûte adhérente, le début de la formation de lamelles (à droite sur la figure); aussi faut-il penser que ce thalle a vécu dans des conditions de vie défectueuses qui ont modifié son aspect habituel et empêché la constitution des lamelles. D'ailleurs M. Foslie avait déjà signalé que le *L. neglectum*, str. sensu, formait quelquefois une croûte adhérente.

Les thalles de *L. neglectum* recueillis par Mrs. Vallentin sont couverts de conceptacles.

Les conceptacles à sporanges sont à peine surélevés au-dessus de la surface du thalle; leur toit est plat; leur diamètre est de 400 μ lorsqu'ils sont de forme circulaire, et de 400 μ × 300 μ ou 400 μ × 500 μ lorsqu'ils sont de forme ovale; le toit est percé de 70 à 80 pores. Je n'ai pas observé de dimension supérieure à 550 μ, bien que l'auteur de l'espèce M. Foslie leur assigne comme dimension 400 à 600 μ.

Les conceptacles à cystocarpes ont sensiblement la même dimension que les précédents; ils ont 400 μ en moyenne, les plus jeunes mesurent 300 à 350 μ et quelques-uns atteignent 450 à 500 μ. Les carpospores mesurent environ 125 μ.

La croûte a une épaisseur de 230 à 330 μ lorsqu'elle forme les lamelles; exceptionellement, lorsqu'elle est adhérente elle atteint 350 μ d'épaisseur et même 600 μ au niveau des conceptacles; elle est presque uniquement constituée par l'hypothalle dont l'épaisseur est d'environ 100 à 150 μ; il est constitué par des files extrêmement serrées, étroites et rigides, difficiles à distinguer les unes des autres; les cellules, étroites et longues mesurent 20 à 40 μ de longueur; dans les échantillons en lamelles la dimension moyenne est plutôt de 25 à 32 μ et dans les échantillons adhérents elle est plutôt de 30 à 37 μ; la largeur est toujours d'environ 7 à 8 μ.

A la partie supérieure de la croûte on remarque un périthalle très réduit composé de quelques cellules formant des files lâches; mais, dans certains échantillons, le périthalle est un peu plus épais et est alors constitué par des rangées superposées; par ce caractère *L. neglectum* doit plutôt appartenir à ce que j'ai appelé la Section V. des *Lithothamnium* tandis que je l'avais précédemment rangé parmi les espèces de la Section II.; mais il faut toutefois

faire cette restriction que ce caractère n'apparaît que sur des croûtes d'une certaine épaisseur.

Les cellules du périthalle mesurent 10 à 16 μ de longueur et 5 à 8 μ de largeur.

J'ai insisté sur cette espèce dont les conceptacles à cystocarpes étaient encore inconnus et dont je n'avais pas eu l'occasion d'étudier les échantillons des Falkland (sub *L. variabile*) dans mon précédent mémoire (1913, pp. 14 et 30).

LITHOTHAMNIUM FUEGIANUM, *Fosl. Alg. Not.* ii. p. 9 (non *Heydr.*). *L. kerguelenum*, Fosl., var. *fuegiana*, Fosl. Schwed. exped. Magellan, p. 69; Lemoine, Rév. Mélob. Ant. p. 29.

E. Falklands: Berkeley Sound, *Skottsberg*.

DISTRIB. Terre de Feu, Iles Falkland.

LITHOPHYLLUM FALKLANDICUM, *Fosl. Alg. Not.* ii. p. 24; *Ant. & Subant. Corall.* p. 14, pl. ii. figs. 10–13; *Lemoine, Rév. Mélob. Ant.* p. 34.

E. Falklands: Berkeley Sound, Stanley Harbour, Port Louis, Seal Cove, *Skottsberg*; W. Falklands, *Vallentin*.

DISTRIB. Cette espèce n'a pas été signalée ailleurs qu'aux Iles Falkland.

Cette espèce est représentée par un seul échantillon sur coquille de *Chiton*. Il est formé d'une croûte mince surmontée de petites nodosités; elle est à un stade encore jeune et elle n'est encore constituée que par le premier tissu, le périthalle primaire. Les conceptacles forment de petits granules convexes, ainsi qu'il est de règle chez cette espèce.

PSEUDOLITHOPHYLLUM DISCOIDEUM, *Lemoine, Rév. Mélob. Ant.* p. 46. *Lithophyllum? discoideum*, Fosl. Schwed. exped. Magellan, p. 73. (Pl. **10**. figs. 1 & 2.)

E. Falklands, *Skottsberg*; W. Falklands, *Vallentin*.

DISTRIB. Espèce caractéristique de la région subantarctique de l'Atlantique: Terre de Feu, Ile des États, Iles Falkland.

Cette espèce est représentée par des croûtes jeunes, de forme circulaire, ayant déjà une assez grande épaisseur et vivant sur coquille de Patelle (Pl. **10**. fig. 1). Un autre échantillon ayant poussé sur rocher est beaucoup plus développé; il forme une croûte basilaire de laquelle s'élèvent des croûtes verticales (Pl. **10**. fig. 2). Tous les échantillons sont couverts de conceptacles qui apparaissent comme de petits points clairs à la surface du thalle et forment ensuite des alvéoles enfoncées dans le thalle. Les échantillons recueillis par Mrs. Vallentin proviennent de la zone littorale; cette espèce a été également recueillie précédemment dans la zone sublittorale.

EPILITHON VALLENTINÆ, *Lemoine*, sp. nov. (Pl. **9**. figs. 3 & 4.)

Crustæ tenuissimæ, primum orbiculares, dein gradatim confluentes et ambitu indeterminatæ, 10–20 μ crassæ, pagina inferiore omnino ad matricem

adnata, paululum calce induratæ, margine lobatæ, mono- vel di-stromaticæ; cellulæ irregulares, subquadraticæ, 3–10 μ longæ, 3–5 μ latæ, et e superficie visæ 14–17 μ longæ, 4–6 μ latæ, dense seriatæ; conceptacula sporangifera 350–400 μ diam., centro deplanata, carposporifera fere convexa centro leviter deplanata, 200–270 μ diam.

Falklands; in *Delesseria Lyallii*, *Vallentin*.

Cette espèce forme de petites croûtes, d'abord isolées, et ensuite confluentes, extrêmement minces, recouvrant les frondes de *Glossopteris Lyallii* (Pl. **9**. fig. 4); l'aspect est très analogue à celui de notre espèce européenne, *E. membranaceum*, de couleur un peu plus rose; la croûte, lobée aux bords, n'a qu'une épaisseur de 10 à 20 μ. Elle est composé de une ou deux rangées de cellules, petites, de forme irrégulière, et se colorant mal par les réactifs; la rangée inférieure est composée de cellules de 3 μ de hauteur et 5 μ de largeur; la rangée supérieure de cellules de 5 à 10 μ de hauteur et 5 μ de largeur. Lorsqu'on observe la thalle à plat, les cellules paraissent disposées en files étroites, rigides, très serrées, et mesurent 14 à 17 μ de longueur et 4 à 6 μ de largeur (Pl. **9**. fig. 3).

Les conceptacles, peu nombreux, sont disséminés ça et là sur le thalle; les conceptacles à sporanges, peu apparents, montrent une partie centrale déprimée entourée d'un rebord peu élevé; le diamètre est de 350–400 μ; les conceptacles à cystocarpes sont peu élevés, ils sont légèrement coniques, et déprimés au sommet, ils mesurent 200 à 270 μ de diamètre.

Le genre *Epilithon* ne renferme qu'un petit nombre d'espèces; les différences qui séparent *E. Vallentinæ* des autres espèces sont faciles à indiquer. Je n'insisterai, parmi les espèces d'*Epilithon*, que sur une espèce du Sud de l'Australie, *E. Rosanoffi*, et sur l'espèce des régions tempérées de l'Atlantique, *E. membranaceum*; les autres espèces d'*Epilithon* sont confinées dans les régions tropicales.

E. Vallentinæ, qui vit sur *Glossopteris*, se distingue facilement de *E. Rosanoffi* qui n'est encore connu que sur *Plocamium*; dans cette dernière espèce le thalle est beaucoup plus épais à l'endroit des conceptacles, il atteint en effet 50 μ d'épaisseur et est constitué en certaines points de 5 rangées de cellules. Les cellules vues de dessus sont beaucoup plus petites que celles de *E. Vallentinæ*: elles mesurent 9–12 $\mu \times 3 \mu$; en coupe (Foslie, Algol. Notiser, v. 1908, p. 5), elles mesurent 7 à 14 $\mu \times 5$ à 9 μ, tandis qu'elles ne dépassent pas 10 μ dans le *E. Vallentinæ*; les conceptacles à sporanges sont plus petits: 150 à 220 μ, leur diamètre extrême est 300 μ.

D'autre part *E. Vallentinæ* paraît assez voisin par l'aspect de *E. membranaceum* qui vit sur un grand nombre de supports. Dans cette dernière espèce, les conceptacles à sporanges ont des rebords plus élevés, et sont presque toujours de forme ovale; leur diamètre n'est que de 110 à 175 μ, ils simulent l'aspect d'un petit cratère, sont généralement en petits groupes et sont souvent confluents. En coupe le tissu est composé de 1 à 4 rangées de

cellules ; enfin les cellules, vues de dessus, sont plus petites et plus larges : elles ne mesurent que 8 à 13 $\mu \times$ 7 à 8 μ. Les conceptacles à cystocarpes ont également un plus faible diamètre et sont plus convexes, ils mesurent 150 à 180 μ. L'espèce *E. Vallentinæ* paraît donc bien caractérisée.

La découverte d'un *Epilithon* dans les régions subantarctiques est fort intéressante. J'avais récemment (1913, p. 54) attiré l'attention sur le petit nombre relatif d'espèces épiphytes dans l'ensemble des régions antarctiques et subantarctiques, et sur l'absence complète des genres de Mélobésiées, *Melobesia* et *Epilithon*. La découverte qu'a faite Mrs. Vallentin modifie les conclusions que j'avais faites à ce sujet et a un grand intérêt.

Species Excludendæ.

Ecklonia buccinalis, *Hornem.*

A Cape plant entirely unknown in the Magellan region. The Falkland Islands record rests on a statement by Bory which was doubtless incorrect.

Punctaria lanceolatum, *Kütz.*

This species, described by Kützing from a specimen of Hooker's from Berkeley Sound, has not been since recorded. The description at once suggests *Corycus prolifer*, but Madame Weber van Bosse informs me that the type-specimen is not to be found in Kützing's herbarium. Specimens of *Corycus prolifer* from Berkeley Sound and agreeing exactly with Kützing's description occur unnamed in the Kew Herbarium, and there can be practically no doubt that it was from a duplicate of this gathering that Kützing founded his *Punctaria lanceolata*. I have therefore removed the name from the list.

Asperococcus bullosus, *Lamx.*

The old record for this (J. Agardh, Sp. i. p. 77 ; *vide* Hariot, '89, p. 44) is doubtless an error for *Adenocystis utricularis*, Skottsb.

Actinonema subtilissima, *Reinsch.* See note below.

A. tenuissima, *Reinsch.*

Both this and the last-named were founded on Falkland Islands material, but the identification of such critical forms from Reinsch's meagre description is quite impossible. The types do not appear to be in existence, hence the names may be removed from algological literature.

Porphyra Kunthii, *Kütz. Phyc. Gen.* p. 393.

I have not seen the type of this doubtful Chilean species and do not know

what it really represents ; but, in any case, Hohenacker's specimen (No. 361), on which the Falklands record is based, appears to be only a form of *P. umbilicalis.*

GIGARTINA PISTILLATA, *Stackh.*
Known from a single species in herb. d'Urville (*vide* Hariot, '89, p. 69). The locality there given is probably incorrect.

GYMNOGONGRUS IMPLICATUS, *Kütz.* (*Ahnfeltia concinna*, Hariot, Miss. Cap Horn, p. 71.)
Howe has recently gone into the question of this species, and he regards it as a variety of *Ahnfeltia Durvillæi*, J. Ag. (Howe, '14, pp. 111–114). The Falkland Islands record is based on Hohenacker, Alg. mar. exsicc. no. 181, which is incorrectly named and is probably a small specimen of *Gracilaria aggregata.*

CALLOPHYLLIS TENERA, *J. Ag.*
It is doubtful if this plant, described from the South Shetlands, is a good species; but, in any case, Hohenacker's Falkland record may be deleted, as his specimen No. 375 is a small thin fragment of *C. fastigiata*, J. Ag.

RHODYMENIA SOBOLIFERA, *Grev.*
An error for *Callophyllis fastigiata*, J. Ag.

CHYLOCLADIA CLAVELLOSA, *Grev.*
Based on an old and very doubtful record by J. Agardh (*vide* Hariot, '89, p. 76).

NITOPHYLLUM FUSCORUBRUM, *Hook. f. et Harv.*
This rests on Hohenacker's Exsicc. no. 198. The species may occur in the Magellan region, but the British Museum example of no. 198 (the only one I have seen) is almost certainly referable to *N. lividum*, Hook. f. et Harv.

N. VARIOLOSUM, *Hook. f.*
J. Agardh records this New Zealand species in his 'Epicrisis' (p. 453), but a specimen so named by him in the British Museum is referable to *N. laciniatum*, Hook. f. et Harv.

DELESSERIA HYPOGLOSSUM, *Lamx.*
See Hariot, '93, p. 93. The specimen is probably *D. phyllophora.*

D. PLATYCARPA, *Lamx.*
Recorded in error. See note under *Nitophylla Durvillei*, J. Ag., p. 182.

LAURENCIA PINNATIFIDA, var. ANGUSTATA, *Hook. f., Fl. Ant.* i. 184; ii. 484.
The Falkland Islands records refer to a species of *Chondria.* See p. 186.

LOPHURA TENUIS, *Kütz.*=*Lophurella Hookeriana*, Falk. See p. 186.

POLYSIPHONIA ATRORUBESCENS, *Grev.*
Hooker's specimen, on which this record is founded, is *P. anisogona*, Hook. f. et Harv.

P. SQUARROSA, *Kütz.*=*Heterosiphonia Berkeleyi*, var. *squarrosa*, Cotton.

POLLEXFENIA TENELLA, *Kütz.*
The question of *Pollexfenia tenella*, founded by Kützing on a plant said to be collected in the Falklands and received from Sir J. D. Hooker, is likely to remain for ever obscure, as Madame Weber van Bosse tells me that the specimen is not to be found in Kützing's herbarium. The genus is unknown in the Antarctic, and the locality is incorrect, hence I have removed the name from the Falkland list.

HALURUS EQUISETIFOLIUS, *Kütz.*
Recorded by Agardh; but, as the plant is not known at all from the Southern hemisphere, doubtlers an error for *Ballia scoparia.*

DUMONTIA FILIFORMIS, *Grev.*
The record for this rests on Hooker's statement in 'Flora Antarctica,' ii. p. 487. An examination of the specimen at Kew and also at the British Museum shows that the plant is not a *Dumontia,* but an alga possessing a cellular structure. The specimens are old, apparently sterile and decayed, and must be left as indeterminable. New Zealand and Campbell Island material under the same cover is also found to be incorrectly named, so that there is now no evidence that *Dumontia filiformis* occurs at all in the Southern hemisphere.

III. SYSTEMATIC LIST OF FRESH-WATER ALGÆ *.

MYXOPHYCEÆ.

CHROOCOCCUS MINUTUS, *Näg. Gatt. einz. Alg.* p. 46.

GLŒOTHECE TEPIDARIORUM, *Lagerh. Bidr. t. Sv. algfl.* p. 44, taf. 1. fig. 12.

OSCILLATORIA PROLIFICA, *Gom. Oscill.* ii. p. 205, taf. 6. fig. 8.

O. SANCTA, *Kütz. Tab. Phyc.* p. 30, taf. 42. fig. 7.

SPIRULINA SUBTILISSIMA, *Kütz. Phyc. gener.* p. 183; *Tab. Phyc.* i. p. 26, taf. 37. fig. 6.

NOSTOC PALUDOSUM, *Kütz. Tab. Phyc.* ii. p. i, fig. 2.

* Compiled from Carlson's 'Süsswasseralgen' (1913), as explained in the Introduction, p. 138.

BACILLARIALES.

MELOSIRA NUMMULOIDES, *Ag.* See Schmidt Atl. taf. 182. fig. 1.

ACHNANTHES BREVIPES, *Ag. Syst.* p. 1.

A. COARCTATA, *Grun., f.* FALKLANDICA, *Carls.* p. 23, taf. 3. figs. 13, 14.

A. LANCEOLATA, *Grun.* Cleve & Grun. Arct. Diat. p. 23.

Var. DUBIA, *Grun.* Cleve & Grun. Arct. Diat. p. 23.

A. MUELLERI, *Carls. Süssw.* p. 23, taf. 3. figs. 5–7.

CALONEIS MACLOVIANA, *Carls. Süssw.* p. 12, taf. 1. fig. 16.

C. PANDURIFORMIS, *Carls. Süssw.* p. 12, taf. 1. fig. 17.

COCCONEIS SCUTELLUM, *Ehrenb. Syn.* ii. p. 170.

CYMBELLA VENTRICOSA, *Kütz. Bac.* p. 80, taf. 6. fig. 16.

DIATOMA ELONGATUM, *Ag. Syst.* p. 4. See *Diatoma tenue,* var. *elongatum,* Heurck, Syn. taf. 1. figs. 18, 19.

DIATOMELLA BALFOURIANA, *Ag.* See Heurck, Syn. p. 161, taf. 51. figs. 10–12.

DIPLONEIS SUBOVALIS, *Cleve, Syn.* i. p. 96, taf. 1. fig. 27.

EPITHEMIA ZEBRA, *Kütz.,* var. PORCELLUS, *Grun. Œsterr. Diat.* p. 328, taf. 3. figs. 3–4.

Var. ELONGATA, *Grun.* Cleve & Möll. Diat. no. 97.

EUNOTIA NYMANNIANA, *Grun. in Heurck, Syn.* taf. 34. fig. 8.

FRAGILARIA RUMPENS, *Grun.* taf. 2. figs. 17, 18.

FRUSTULIA RHOMBOIDES, *Cleve, Syn.* i. p. 122.

F. VULGARIS, *Cleve, Syn.* i. p. 122.

GRAMMATOPHORA OCEANICA, *Ehrenb.* See Grun. Grammat. p. 9.

*GYROSIGMA ATTENUATUM, *Rab.,* var. SUBBALTICUM, *Carls.* p. 13, taf. 2. figs. 4–6.

NAVICULA CRYPTOCEPHALA, *Kütz. Bac.* p. 94, taf. 3. fig. 26.

N. EXCELLENS, *Carls.* p. 16, taf. 1. fig. 27.

N. KOTSCHYI, *Grun. Neue u. ungenüg. gek. Algen,* p. 538, taf. 4. fig. 12.

N. MUTICA, *Kütz.,* var. PRODUCTA, *Grun. in Cleve & Grun. Arct. Diat.* p. 41.

NAVICULA SUECORUM, *Carls. Süssw.* p. 15, taf. 1. fig. 27.

NITZSCHIA SIGMA, *W. Sm. Brit. Diat.* i. p. 39, tab. 13. fig. 108.

PINNULARIA BOREALIS, *Ehrenb. Verbr. u. Einfl.* taf. i. 2, fig. 6.

P. INTERRUPTA, *W. Sm., f.* STAURONEIFORMIS, *Cleve, Syn.* ii. p. 76.

P. MACILENTA, *Ehrenb.* Cleve, Diat. Finl. p. 24, taf. 1. fig. 7.

P. STAUROPTERA, *Rab.*, var. INTERRUPTA, *Cleve, Syn.* ii. p. 83.

P. VIRIDIS, *Ehrenb. Infus.* p. 182.

PSEUDONITZSCHIA MIGRANS, *Heurck, Diat. Exp. ant.* p. 23, tab. 3. fig. 44.

RHOPALODIA GIBBERULA, *O. Müll. Bac. El Kab.* p. 276.

SURIRELLA OVALIS, *De Toni, Syll.* ii. p. 579.

SYNEDRA AFFINIS, *Kütz.*, var. TABULATA, *Heurck, Syn.* taf. 41. fig. 14.

S. FULGENS, *W. Sm.*, var. MEDITERRANEA, *Grun. in Heurck, Syn.* taf. 43. fig. 3.

TRACHYNEIS ASPERA, *Cleve, Syn.* i. p. 191. See Schmidt, Atl. taf. 48. figs. 2–6.

HETEROKONTÆ.

TRIBONEMA BOMBYCINUM, *Derb. & Sol. Süssw. Alg. Schl.-Holst.* i. p. 132.

CHLOROPHYCEÆ.

CŒLASTRUM SPHÆRICUM, *Näg. Gatt. einz. Alg.* p. 97, taf. 5 C. fig. 1.

GLŒOCYSTIS VESICULOSA, *Näg. Gatt. einz. Alg.* p. 65, taf. 4.

HORMOTILA MUCIGENA, *Borzi, Studi Algol.* i. p. 99, tab. 8., 9.

PLEUROCOCCUS VULGARIS, *Menegh.* See G. S. West, Brit. Freshw. Algæ, p. 202, fig. 81.

TROCHISCIA GRANULATA, *Hansg. Ueber Trochiscia*, p. 128.

T. HYSTRIX, *Hansg. Ueber Trochiscia*, p. 129.

TRENTEPOHLIA POLYCARPA, *Nees & Mont. Voy. de la 'Bonite,'* p. 16.

ULOTHRIX ÆQUALIS, *Kütz. Phyc. Germ.* p. 196 ; *Tab. Phyc.* ii. taf. 89. fig. 1.

U. OSCILLARINA, *Kütz. Phyc. Germ.* p. 197 ; *Tab. Phyc.* ii. taf. 88. fig. 1.

PRASIOLA CRISPA, *Menegh. Cenni sull' Organographia*, p. 36.

IV. SYSTEMATIC LIST OF LICHENS.

The sequence of genera is that of Darbishire's 'Lichens of the Swedish Antarctic Expedition' (1912).

SPHÆROPHORON COMPRESSUM, *Ach. Meth.* p. 135.
E. Falklands, *Gaudichaud, Hooker*; Port Louis, Port Stanley, *Skottsberg.* W. Falklands; Shallow Bay, *Vallentin.*
DISTRIB. Cosmopolitan.

S. CORALLOIDES, *Pers. in Ust. Ann.* i. (1791) p. 23.
E. Falklands, *Hooker*: Port Louis, Port Stanley, *Skottsberg.* W. Falklands; Hill Cove, Mount Cook, Roy Cove, *Vallentin.*
DISTRIB. Cosmopolitan.

S. TENERUM, *Laurer, in Linnæa,* ii. (1827) p. 45, t. 1. fig. 4.
E. Falklands; Port Stanley, *Skottsberg.*
DISTRIB. Fuegia, Patagonia, S. Chile, Southern Australia.

LECIDIA AGELLATA, *Darb. Lich. Swed. Ant. Exped.* p. 4, pl. 1. fig. 3.
E. Falklands; Port Louis, *Skottsberg.*
DISTRIB. Falkland Islands.

L. CAPISTRATA, *Darb. Lich. Swed. Ant. Exped.* p. 3, pl. 1. fig. 2.
E. Falklands; Port Louis, *Skottsberg.*
DISTRIB. Falkland Islands.

L. ELÆOCHROMA, *Th. Fr. Lich. Scand.* p. 542. *L. parasema,* Hook. Fl. Ant. ii. p. 539, *non* Ach.
E. Falklands; Port Stanley, *Skottsberg.*
DISTRIB. Cosmopolitan.

L. ELATA, *Schaer. Spic.* p. 137.
E. Falklands; Port Stanley, *Skottsberg.*
DISTRIB. Arctic regions and alpine Europe.

L. HUMISTRATA, *Nyl. Lich. Nov. Zel.* p. 146. *Biatora humistrata,* Flotow.
E. Falklands, *Lechler.*
DISTRIB. Falkland Islands.

L. INTERRUPTA, *Darb. Lich. Swed. Ant. Exped.* p. 3, pl. 1. fig. 1.
E. Falklands; Port Stanley, *Skottsberg.*
DISTRIB. Falkland Islands.

LECIDIA PROTRACTA, *Darb. Lich. Swed. Ant. Exped.* p. 4, pl. 1. fig. 4.
E. Falklands, *Skottsberg.*
DISTRIB. Falkland Islands.

L. TENEBROSULA, *Müll.-Arg. in Flora*, lxix. (1886) p. 126.
E. Falklands ; Port Stanley, *Skottsberg.*
DISTRIB. Falkland Islands, S. Georgia.

L. XANTHOLEUCA, *Müll.-Arg. Lich. Speg.* p. 45.
E. Falklands ; Port Stanley, *Lechler*, 56.
DISTRIB. Falkland Islands.

BIATORA MACLOVIANA, *Flotow, Deutsche Lich. Exsicc.* 61 (nomen nudum ?); *Lechler, Enumeratio*, p. 49.
E. Falklands, *Lechler.*
DISTRIB. Falkland Islands.
Apparently a *nomen nudum.*

BACIDIA TUBERCULATA, *Darb. Lich. Swed. Ant. Exped.* p. 5, pl. 1. fig. 8.
E. Falklands ; Port Louis, *Skottsberg.*
DISTRIB. Falkland Islands.

RHIZOCARPON GEMINATUM, *Th. Fr. Lich. Scand.* p. 623.
E. Falklands ; Port Louis, *Skottsberg.*
DISTRIB. Arctic, antarctic, and alpine regions, probably cosmopolitan.

R. GEOGRAPHICUM, *DC. Fl. Franç.* ii. p. 366.
E. Falklands, *d'Urville, Hooker* ; Port Stanley, Port Louis, *Skottsberg.* W. Falklands ; Roy Cove, common, *Vallentin.*
DISTRIB. Arctic, antarctic, and alpine regions, cosmopolitan.

STEREOCAULON MAGELLANICUM, *Th. Fr. Comm.* p. 31. *S. tomentosum*, var. *magellanicum*, Crombie, Lichens Nassau, p. 224.
W. Falklands ; Fox Bay, *Cunningham.*
DISTRIB. Fuegia.

S. TURFOSUM, *Bory in d'Urville, Flore des Mal.* p. 596.
E. Falklands, *d'Urville.*
DISTRIB. Falkland Islands.
This is probably a synonym of the last.

CLADONIA AGGREGATA, *Eschw. in Mart. Fl. Bras.* i. (1833) p. 278. *Cenomyce aggregata*, Ach. ; Hook. f. Fl. Ant. ii. p. 532.
E. Falklands, *Gaudichaud, Hooker* ; Port Stanley, Port Louis, *Skottsberg.* W. Falklands ; Hill Cove, *Vallentin.*
DISTRIB. Mainly southern part of America, Africa, and Australia.

CLADONIA CARIOSA, *Spreng. Syst. Veg.* iv. p. 272.
W. Falklands ; Roy Cove, Shallow Bay, *Vallentin.*
DISTRIB. Probably cosmopolitan.

C. CERVICORNIS, *Schaer.* p. 195.
W. Falklands ; Rapid Point, Roy Cove, Mount Cook, *Vallentin.*
DISTRIB. Europe, Asia, Africa.
This and the last are both additions to the list.

C. COCCIFERA, *Schaer. Spic.* p. 24. *Cenomyce coccifera,* Hook. f. Fl. Ant. ii. p. 531.
E. Falklands, *Hooker* ; Port Louis, *Skottsberg.* W. Falklands ; Hill Cove, in profusion, *Vallentin.*
DISTRIB. Probably cosmopolitan.

C. DEFORMIS, *Hoffm. Deutsch. Fl.* ii. p. 120. *Cenomyce deformis,* Ach. ; Hook. f. Fl. Ant. ii. p. 531.
E. Falklands, *d'Urville, Hooker.*
DISTRIB. Probably cosmopolitan.

C. FIMBRIATA, *Fr. Lich. Eur.* p. 222. *Cenomyce fimbriata,* Ach. ; Hook. f. Fl. Ant. ii. p. 531.
E. Falklands, *d'Urville, Hooker.* W. Falklands ; Shallow Cove, Crooked Inlet, Turkey Inlet, *Vallentin.*
DISTRIB. Cosmopolitan.

C. FURCATA, *Hoffm. Deutsch. Fl.* ii. p. 115.
E. Falklands ; Port Louis, *Skottsberg.* W. Falklands ; Roy Cove, *Vallentin.*
DISTRIB. Cosmopolitan.

C. GRACILIS, *Hoffm. Deutsch. Fl.* ii. p. 119. *Cenomyce gracilis,* Ach. ; Hook. f. Fl. Ant. ii. p. 331.
E. Falklands, *Hooker* ; Port Stanley, *Skottsberg.* W. Falklands ; Mt. Cook, 800 ft., rare, *Vallentin.*
DISTRIB. Europe, N. & S. America, Antarctic islands.

C. MACILENTA, *Hoffm. Deutsch. Fl.* ii. p. 126. *Cœnomyce bacillaris,* Ach. ; Hook. f. Fl. Ant. ii. p. 532.
E. Falklands, *Hooker* ; Port Stanley, *Skottsberg.*
DISTRIB. Probably cosmopolitan.

CLADONIA PYCNOCLADA, *Nyl. Lich. Nov. Zel.* p. 244.

E. Falklands, *Gaudichaud*; Port Louis, *Skottsberg*; Roy Cove, *Vallentin.*

DISTRIB. Mascarenes, Brazil, Colombia, Fuegia, New Zealand.

C. PYXIDATA, *Fr. Lich. Eur.* p. 216.

E. Falklands, *d'Urville, Firmin*; Port Louis, *Skottsberg.* W. Falklands; Roy Cove, *Vallentin.*

DISTRIB. Cosmopolitan.

C. RANGIFERINA, *Ach. Lich. Univ.* p. 564.

E. Falklands, *d'Urville, Hooker.* W. Falklands; Roy Cove, Hill Cove, *Vallentin.*

DISTRIB. Cosmopolitan.

C. VERTICILLATA, *Floerke, Clad.* p. 26.

W. Falklands; Roy Cove, *Vallentin.*

DISTRIB. Cosmopolitan.

OCHROLECHIA PARELLA, *Massal. Ricerche,* p. 32. *Lecanora parella,* Ach.; Hook. f. Fl. Ant. ii. p. 536.

E. Falklands, *Hooker*; Port Louis, Port Stanley, Duperry Harbour, *Skottsberg.* W. Falklands; Roy Cove, *Vallentin.*

DISTRIB. Cosmopolitan.

O. TARTAREA, *Massal. Ricerche,* p. 30. *Lecanora tartarea,* Ach.; Hook. f. Fl. Ant. ii. p. 536.

E. Falklands, *d'Urville, Hooker*; Port Stanley, Port Louis, *Skottsberg.* W. Falklands; Fox Bay, Roy Cove, Shallow Bay, *Vallentin.*

DISTRIB. Europe, Asia, America.

A verruculose form, resembling *O. upsaliensis* in habit, is frequent "on bogs of *Lomaria magellanica* (=*Blechnum tabulare,* Kuhn) where camp-fires have killed the vegetation."

O. UPSALIENSIS, *Massal. Ricerche,* p. 31. *Lecanora parella,* var. *upsaliensis,* Ach.; Hook. f. Fl. Ant. ii. p. 536. *L. macloviana,* Pers. in Gaud. Voyage, p. 97.

E. Falklands, *Gaudichaud, Hooker.*

DISTRIB. Europe, N. America.

PERTUSARIA ALTERIMOSA, *Darb. Lich. Swed. Ant. Exped.* p. 7, pl. 1. fig. 11.

E. Falklands; Port Louis, *Skottsberg.*

DISTRIB. Falkland Islands.

Pertusaria corrugata, *Darb. Lich. Swed. Ant. Exped.* p. 6, pl. 1. fig. 10.
E. Falklands ; Port Stanley, *Skottsberg.*
Distrib. Falkland Islands.

P. erubescens, *Nyl. in Lechler, Plant. Maclov.* no. 57 ; *Lich. Fueg. et Pat.* p. 22.
E. Falklands, *Lechler*, 57.
Distrib. Falkland Islands.
Both this and the next are very little known plants, and should be redescribed from the type-specimens.

P. macloviana, *Müll.-Arg. in Flora,* xlii. (1884) p. 271.
E. Falklands, *Lechler,* 54.
Distrib. Falkland Islands.

P. solitaria, *Darb. Lich. Swed. Ant. Exped.* p. 7, pl. 1. fig. 12.
E. Falklands ; Port Louis, *Skottsberg.*
Distrib. Falkland Islands.

Candelaria concolor, *Th. Fr. Lich. Scand.* p. 417. *Lecanora candelaria,* Ach. ; Hook. f. Fl. Ant. ii. p. 537. *L. laciniosa*, Nyl. in Flora, xxxix. (1881) p 454.
E. Falklands ; on twigs of *Acæna*, Hooker.
Distrib. Probably cosmopolitan.

Xanthoria lychnea, *Th. Fr. Lich. Scand.* p. 416.
E. Falklands ; Port Louis, *Skottsberg.* W. Falklands ; Roy Cove (on gate-posts), Crooked Inlet, *Vallentin.*
Distrib. Probably cosmopolitan.

Placodium ambitosum, *Darb. Lich. Swed. Ant. Exped.* p. 18, pl. 2. fig. 13.
E. Falklands ; Port Louis, *Skottsberg.* W. Falklands ; Roy Cove, *Vallentin.*
Distrib. Falkland Islands.
Some fine material of this beautiful new species described by Darbishire in 1912 was collected by Mrs. Vallentin at Roy Cove. Known at present only from the Falkland Islands.

P. lucens, *Nyl. Lich. Nov. Zel.* p. 145. *Lecanora murorum,* var. *farcta,* Church. Bab. ; Hook. f. Fl. Ant. ii. p. 535.
E. Falklands ; Port Stanley, *Skottsberg.*
Distrib. Kerguelen, Cape Horn.

PLACODIUM MURORUM, *DC. Fl. Fr.* ii. p. 378. *Lecanora murorum*, Ach.; Hook. f. Fl. Ant. ii. p. 535, excl. var.

E. Falklands, *Hooker*.

Var. MINIATUM, *H. Olivier, Lich. d'Eur.* p. 89. *Lecanora miniata*, Ach.; Hook. f. Fl. Ant. ii. p. 535.

E. Falklands, *Hooker*.

DISTRIB. Type and variety probably cosmopolitan.

HÆMATOMMA COCCINEUM, *Koeber, Syst. Lich. Gen.* p. 153. *Lecanora hæmatomma*, Ach.; Hook. f. Fl. Ant. ii. p. 537.

E. Falklands, *Hooker*; Port Stanley, Port Louis, *Skottsberg*. W. Falklands; Roy Cove, Crooked Inlet, *Vallentin*.

DISTRIB. Europe, N. & S. America.

H. VENTOSUM, *Massal. Ricerche*, p. 33, fig. 54. *Lecanora ventosa*, Ach.; Hook. f. Fl. Ant. ii. p. 537.

E. Falklands, *Hooker*; Port Louis, *Skottsberg*.

DISTRIB. Probably cosmopolitan.

LECANORA ATRO-VIOLACEA, *Nyl. Lich. Fueg.* p. 21.

E. Falklands, *Lechler*.

DISTRIB. Falkland Islands.

L. EPIBRYON, *Ach. Syn.* p. 155. *L. subfusca*, var. *epibryon*, Ach.; Hook. f. Fl. Ant. ii. p. 536.

E. Falklands, *Hooker*, *Skottsberg*.

DISTRIB. Probably cosmopolitan.

L. ERYTHRELLA, *Nyl. & Cromb. in Journ. Linn. Soc., Bot.* xx. (1883) p. 63.

E. Falklands; Port William, *Hooker*.

DISTRIB. Cosmopolitan.

Hooker's specimen is not to be found at Kew, and it is not certain whether the plant is the same as *L. erythrella* as at present understood.

L. FRUSTULOSA, *Ach. Lich. Univ.* p. 405.

E. Falklands; Port Stanley, *Skottsberg*.

DISTRIB. Europe, E. Asia, northern and alpine America.

L. SUBFUSCA, *Nyl. in Flora*, lv. (1872) p. 250.

E. Falklands, on *Acæna*, Hooker.

DISTRIB. Cosmopolitan.

Aspicillia lirellina, *Darb. Lich. Swed. Ant. Exped.* p. 10, pl. 2. figs. 18 & 19.

E. Falklands; Port Louis, *Skottsberg.*

Distrib. Falkland Islands.

A. orbiculata, *Darb. Lich. Swed. Ant. Exped.* p. 11, pl. 2. fig. 21.

E. Falklands; Port Louis, *Skottsberg.*

Distrib. Falkland Islands.

Parmelia antarctica, *Bitter, in Hedwigia*, xl. (1901) p. 248, t. 10. fig. 3.

W. Falklands; Hill Cove, *Vallentin.*

Distrib. New Zealand.

The stalk is undoubtedly hollow in some parts of the gathering, in others it is doubtful, but I have referred the specimens to *P. antarctica.*

P. Borreri, *Turn. in Trans. Linn. Soc.* ix. (1808) p. 148, t. 13. fig. 2.

W. Falklands; Shallow Bay, *Vallentin.*

Distrib. Cosmopolitan.

Several specimens with the punctate soredia typical of this species were collected. It, together with the last, is an addition to the Falklands list.

P. enteromorpha, *Ach. Meth.* p. 252; *Hook. f. Fl. Ant.* ii. p. 532.

E. Falklands, *Hooker, Linney*; Port Stanley, Port Louis, *Skottsberg.* W. Falklands, *Firmin.*

Distrib. America, Australia, New Zealand.

See note under next species.

P. lugubris, *Pers. in Gaud. Flora*, p. 196.

E. Falklands, *Gaudichaud, d'Urville.* W. Falklands; Roy Cove, on *Empetrum rubrum*, common, *Vallentin.*

Distrib. Southern America, N. Asia.

For the determination of the *Hypogymnia* section of *Parmelia*, Bitter's important paper ('01) should be consulted. According to his classification the plant which Mrs. Vallentin found so plentifully on *Empetrum rubrum* is referable to *P. lugubris* rather than to *P. enteromorpha.* Probably the bulk of Hooker's material belongs to the same species, though referred by him to *P. enteromorpha.*

Several lichens are known to be carried large distances by the wind, and Mrs. Vallentin records in her note-book that this is particularly the case in the present species, owing to the thallus being so much inflated with air.

PARMELIA MOUGEOTII, *Schaer. Enum.* p. 46.
E. Falklands; Duperry Harbour, *Skottsberg.*
DISTRIB. Probably cosmopolitan.

P. SAXATILIS, *Ach. Syn.* p. 203; *Hook. f. Fl. Ant.* ii. p. 332.
E. Falklands, *Gaudichaud*, *Hooker*; Port Stanley, Port Louis, Duperry Harbour, *Skottsberg.* W. Falklands; Roy Cove, *Vallentin.*
DISTRIB. Cosmopolitan.

CETRARIA ACULEATA, *Fr. Sched. Crit.* ix. p. 32.
E. Falklands; Port William, *Lechler*, 73 & 81. W. Falklands; Mount Cook, *Vallentin.*
DISTRIB. All continents except Australia.

C. ISLANDICA, *Ach. Meth.* p. 293.
W. Falklands; Mount Cook, *Vallentin.*
DISTRIB. All continents except Australia.

USNEA ANGULATA, *Ach. Syn.* p. 307.
E. Falklands, *Hooker.*
DISTRIB. Central and South America; southern Australia.
For assistance with the Usneæ I am much indebted to Miss A. Lorrain Smith. A single specimen, about one foot long, with an angular and lacunose stem, collected by Hooker, we have referred to this species.

U. ARTICULATA, *Hoffm. Fl. Germ.* p. 135. *U. barbata*, var. *articulata*, Ach.; Hook. f. Fl. Ant. ii. p. 521.
E. Falklands, *Hooker*, *Wright.* W. Falklands; Crooked Inlet, Roy Cove, Port Egmont, *Vallentin.*
DISTRIB. Cosmopoliton.
Miss Lorrain Smith agrees with me in referring a lax and slightly branched *Usnea* resting lightly on *Empetrum rubrum* to a form of this species. The main branches are 2–3 mm. wide, and but sparingly articulate. "Very delicate in form and colour; not common."

U. FLORIDA, *Ach. Lich. Univ.* p. 304.
E. Falklands, *Hooker.* W. Falklands; Crooked Inlet, Roy Cove, *Vallentin.*
DISTRIB. Cosmopolitan.
Several specimens found on a gate-post appear to be referable to dwarf forms of *U. florida*. Similar specimens found on twigs agree well with f. *denudata*, Wainio ('03, p. 10).

Neuropogon melaxanthum, *Nyl. Syn.* p. 272.

E. Falklands, *Gaudichaud*, *d'Urville*, *Hooker*, *Cunningham*, *Linney*, *Skottsberg*. W. Falklands, several localities, *Firmin*, *Vallentin*.

Distrib. Arctic, antarctic, and alpine regions.

Some exceedingly fine specimens from an exposed headland on Saunders Island were brought home by Mrs. Vallentin. Hooker, who devotes considerable space to *N. melaxanthum*, remarks:—"It is in the Falkland Islands that this species most abounds, covering the surface of the quartz rocks with a miniature forest, seeking the most exposed situations, and there attaining its greatest size and beauty. In these islands, too, all the five varieties I have enumerated may be found growing within a few feet of each other, and so associated as to leave little doubt that they are states depending on age rather than marked races" (Fl. Ant. ii. p. 520).

N. trachycarpum, *Stirt. Gen.* Usnea, p. 7.

E. Falklands; Port Stanley, *Skottsberg*.

Distrib. Southern parts of S. America.

Alectoria ochroleuca, *Nyl. Prodr.* p. 47.

E. Falklands, *Hooker*.

Distrib. Alpine regions, cosmopolitan.

A single specimen of *A. ochroleuca* was found under *Usnea barbata* in Hooker's herbarium.

Ramalina linearis, *Ach. Lich. Univ.* p. 598.

E. Falklands; Port Stanley, *Skottsberg*.

Distrib. Probably cosmopolitan.

Most of the old records of *R. linearis* and *R. scopulorum* refer to *R. terebrata*. Darbishire, however, who lists *R. terebrata* from Fuegia, records *R. linearis* also as gathered by Skottsberg at Port Stanley.

R. scopulorum, *Ach. Lich. Univ.* p. 640; *Hook. f. Fl. Ant.* ii. p. 522, var. α.

E. Falklands, *Hooker*; Port Louis, *Skottsberg*. W. Falklands, *Vallentin*.

Distrib. Probably cosmopolitan.

One has only to refer to Miss Knowles's interesting account of the *Ramalina* vegetation and its ecology ('13, pp. 87–101) to appreciate the difficulty of naming foreign material. In spite of careful study, Miss Knowles finds it exceedingly difficult to place many of the British maritime forms according to the present classification, and she is inclined to take a wide view as to the limits of *R. scopulorum*.

R. terebrata, the common form in the Falklands, is allied to this species, but it is well marked and sufficiently distinct, until further information is

forthcoming, to be kept up as a species. Certain plants brought home by various collectors are, however, almost identical with *R. scopulorum*, and hence the species is still listed for our area.

RAMALINA TEREBRATA, *Taylor & Hook. f. in Lond. Journ. Bot.* iii. (1844) p. 654. *R. scopulorum*, var. *terebrata*, Hook. f. Fl. Ant. ii. p. 522.

E. Falklands, *d'Urville, Hooker.* W. Falklands, *Firmin*; Roy Cove, Crooked Inlet, Hill Cove, *Vallentin.*

DISTRIB. Fuegia, Graham Land.

See notes above.

BUELLIA DISCRETA, *Darb. Lich. Swed. Ant. Exp.* p. 14, pl. 3. fig. 25.

E. Falklands; Port Louis, *Skottsberg.*

DISTRIB. Falkland Islands.

B. FALKLANDICA, *Darb. Lich. Swed. Ant. Exp.* p. 14, pl. 3. fig. 26.

E. Falklands; Port Louis, *Skottsberg.*

DISTRIB. Falkland Islands.

PANNARIA MUSCORUM, *Nyl. Lich. Scand.* p. 27. *Lecanora muscorum*, Ach.; Hook. f. Fl. Ant. ii. p. 534.

E. Falklands, *d'Urville, Hooker.*

DISTRIB. Probably cosmopolitan.

PSOROMA PALEACEUM, *Nyl. Syn.* ii. p. 22. *Lecanora paleaca*, Fr.; Hook. f. Fl. Ant. ii. p. 36.

E. Falklands, *Hooker.*

DISTRIB. Europe; S. America.

Hooker's specimens of this species are not to be found at Kew.

P. HYPNORUM, *Hoffm. Fl. Germ.* ii. p. 166.

E. Falklands, *Lechler*; Port Louis, *Skottsberg.* W. Falklands, Roy Cove, Shallow Bay, Hill Cove, *Vallentin.*

DISTRIB. Upland regions, probably cosmopolitan.

STICTA ENDOCHRYSA, *Delise, Genre* Sticta, p. 43, tab. 1; *Hook. f. Fl. Ant.* ii. p. 525, partim, excl. syn. *S. Lechleri*, Flot. (*non* Müll.) in Lechler, no. 65 *a.*

E. Falklands, *Gaudichaud, d'Urville, Hooker*; Port Stanley, *Lechler, Linney.* W. Falklands, *Firmin*; Rapid Point, Roy Cove, Crooked Inlet, *Vallentin.*

DISTRIB. Chile, Patagonia, Fuegia, S. Georgia.

S. endochrysa has been much confused in the past with *S. Urvillei.*

Hooker's gatherings were composed largely of the latter, and it is probable that the same applies to the earlier French records referred to above. Several very fine specimens of the true *S. endochrysa* were collected by Mrs. Vallentin.

Sticta Freycinetii, *Delise, Genre* Sticta, p. 124, tab. 14. fig. 51 ; *Hook. f. Fl. Ant.* ii. p. 528 (*non* i. p. 196). *S. lactucæfolia*, Pers. in Gaud. Voyage, p. 199.

E. Falklands, *Gaudichaud, Hooker*. W. Falklands ; Roy Cove, Crooked Inlet, Hill Cove, *Vallentin*.

Distrib. Australia, New Zealand, S. America, S. Georgia.

S. Urvillei, *Delise, Genre* Sticta, p. 170. *S. endochrysa*, Hook. f. Fl. Ant. ii. p. 525, partim (*non* Delise). *S. flavicans*, Hook. f. et Tayl. in Lond. Journ. Bot. iii. (1844) p. 648.

E. Falklands, *Hooker* (frequent) ; Port Stanley, Port Louis, *Skottsberg*. W. Falklands ; Rapid Point, *Vallentin*.

Var. orygmæoides, *Nyl. Syn.* i. p. 360.

W. Falklands ; Crooked Inlet, *Vallentin*.

Distrib. S. America, S. Africa, Australia, New Zealand.

Probably collected by other botanists and referred to *S. endochrysa* (see note above). For assistance with this and other species of *Sticta* I am indebted to Dr. L. W. Riddle, who has special knowledge of the group and who was on a visit to Kew when the material was being investigated.

Stictina carpoloma, *Nyl. in Flora*, xliii. (1860) p. 66 ; *Syn.* p. 339. *Sticta carpoloma*, Delise, Genre *Sticta*, p. 159. *S. gyrosa*, Flotow in Lechler, Pl. Maclov. no. 66.

E. Falklands, *Lechler*.

Distrib. Australia, New Zealand, S. America, Java, Polynesia.

It is doubtful whether this plant really occurs in the islands. Flotow's *S. gyrosa* has been referred in the past to *S. carpoloma*, but the Kew specimen of his Falkland Islands gathering must be regarded as a form of *S. Freycinetii*.

S. crocata, *Nyl. in Flora*, xliii. (1860) p. 66 ; *Syn.* p. 338.

E. Falklands, *Gaudichaud, d'Urville* ; Port Stanley, *Skottsberg*. W. Falklands ; Shallow Bay, *Vallentin*.

Distrib. Cosmopolitan.

S. filicina, *Nyl. in Flora*, xliii. (1860) p. 66 ; *Syn.* p. 349.

E. Falklands ; Port Louis, *Skottsberg*.

Distrib. S. America, New Zealand, Java.

STICTINA GAUDICHAUDII, *Nyl. Syn.* i. p. 345. *Sticta malovina*, Fr. Syst. Orb. Veg. p. 283.

E. Falklands, *Gaudichaud.*

DISTRIB. Falklands.

According to Malme ('99, p. 12), *Sticta malovina*, Fr., is a synonym of the old *S. Gaudichaudii* of Delise.

S. GILVA, *Nyl. Syn.* p. 339. *Sticta crocata*, var. *gilva*, Ach. Syn. p. 232; Hook. f. Fl. Ant. ii. p. 525 (excl. syn.). *Collema lanatum*, Pers. in Gaud. Flore des Malouines, p. 97.

E. Falklands, *Hooker*; Duperry Harbour, *Skottsberg.* W. Falklands; Roy Cove, *Vallentin.*

DISTRIB. S. Africa, Australia, Java, Fuegia.

S. INTRICATA, var. THOUARSII, *Nyl. Syn.* p. 335. *Sticta Thouarsii*, Del. Genre *Sticta*, p. 90, tab. 8. fig. 29; Hook. Fl. Ant. ii. p. 527.

E. Falklands, *Hooker.*

DISTRIB. Europe, Africa, America.

Hooker records this from the Falkland Islands (Fl. Ant. *l. c.*), but no specimen can be found in the Kew collection.

PELTIGERA CANINA, *Schaer. Enum.* p. 20; *Hook. f. Fl. Ant.* ii. p. 524.

E. Falklands, on *Bolax glebraria*, Hooker.

DISTRIB. All continents except Australia.

The record rests on a single imperfect specimen of Hooker's; the plant is, however, known from the adjoining mainland.

P. MALACCA, *Fr. Lich. Eur.* p. 44.

E. Falklands; Port Louis, *Skottsberg.*

DISTRIB. Cosmopolitan.

P. POLYDACTYLA, *Hoffm. Fl. Germ.* ii. p. 106.

E. Falklands; Port Louis, *Skottsberg.* W. Falklands; Roy Cove, *Vallentin.*

DISTRIB. Cosmopolitan.

P. RUFESCENS, *Hoffm. Fl. Germ.* ii. p. 107.

E. Falklands; Port Louis, *Skottsberg.* W. Falklands, Crooked Inlet, *Vallentin.*

DISTRIB. Cosmopolitan.

VERRUCARIA DERMOPLACA, *Crombie, Lichens of 'Nassau,'* p. 234.

W. Falklands; Fox Bay, *Cunningham.*

DISTRIB. Falkland Islands.

VERRUCARIA FALKLANDICA, *Nyl. Lich. Fuegia*, p. 22.
Falkland Islands, *Rabenhorst fil.*
DISTRIB. Falkland Islands.
Only known from Nylander's description.

V. GLAUCOPLACOIDES, *Darb. Lichens Swed. Ant. Exped.* p. 18, pl. 3. figs. 34 & 35.
E. Falklands; Port Louis, Mount Vernet, *Skottsberg.*
DISTRIB. Falkland Islands.

PORINA CONFUSUM, *Bory in d'Urville, Flore des Malouines*, p. 595.
E. Falklands, *d'Urville.*
DISTRIB. Falkland Islands.

EODOCARPUM MACLOVIANUM, *Bory in d'Urville, Flore des Malouines*, p. 595.
E. Falklands, *d'Urville.*
DISTRIB. Falkland Islands.

THAMNOLIA VERMICULARIS, *Schaer. Enum.* p. 243. *Cenomyce vermicularis*, Ach., Hook. Fl. Ant. ii. p. 532.
E. Falklands, *d'Urville.* W. Falklands; Ella Hill, Roy Cove, at 500 ft., rare, *Vallentin.*
DISTRIB. Alpine regions, cosmopolitan.

T. UNDULATA, *Nyl. Syn.* p. 265.
E. Falklands, *d'Urville.*
DISTRIB. Falkland Islands.
A little-known plant, and probably a synonym of the last.

NOTE ON SOME OF THE OLDER NAMES.

The present position of some of the plants named by the early authors is difficult to trace. The following list gives the synonymy, as decided by various authorities, in those cases where it is not easily discoverable or otherwise obscure:—

Collema lanatum, Pers.	=	STICTINA GILVA, Nyl.
Cornicularia flavicans, Pers.	=	NEUROPOGON MELAXANTHUM, Nyl.
Parmelia pubescens, Pers.	=	STICTA ENDOCHRYSA, Del.
Physcia sepiacea, Pers.	=	RAMULINA TEREBRATA, Tayl. & Hook.
Ramalina flaccidissima, Pers.	=	,, ,, ,,
Sticta citrina, Pers.	=	STICTINA CROCATA, Nyl.
S. lactucæfolia, Pers.	=	STICTA FREYCINETII, Del.
S. Lechleri, Flot., *non* Müll.	=	S. ENDOCHRYSA, Del.
S. gyrosa, Flot.	=	STICTINA CARPOLOMA, Del.

V. SYSTEMATIC LIST OF FUNGI.

The sequence of genera is that of Saccardo's 'Sylloge Fungorum,' except that the Discomycetes immediately follow the Pyrenomycetes.

ANTENNARIA ROBINSONII, *Mont. Syll. Crypt.* p. 290. no. 1066; *Berk. et Mont. in Hook. Lond. Journ. Bot.* ii. (1843) p. 640, tab. 24. fig. 2.

W. Falklands; on *Baccharis magellanica*, Roy Cove, *Vallentin.*

DISTRIB. South America, Australia, New Zealand.

The genus is new to the Falklands, and, strangely enough, in the wooded district of Fuegia, where it might have been expected, it was neither found by Hariot nor Spegazzini.

A. Robinsonii was originally described from material collected at Juan Fernandez, specimens of which exist at Kew. The diagnosis was scanty, but the plant has been recorded from many other parts of the world, including N. America, Africa, and Australia, its short growth and slender filaments marking it off from *A. scoriadea*, *Scorias spongiosa*, and other well-known southern forms. The genus *Antennaria* is badly in need of revision, and it is impossible to state the exact distribution of *A. Robinsonii* or the exact limits of the species.

The original specimens, on leaves of a fern, show a creeping, torulose, non-punctate mycelium, consisting either of very short cells hardly longer than broad or of oblong cells measuring $15\text{–}18 \times 6\text{–}8\ \mu$. The same diversity is seen in the upright branches, though the majority are of the long-celled type. The rudiments of laterally-borne perithecia are visible, but these are too young to show spores. A few stouter filaments, consisting of barrel-shaped cells $15\text{–}18\ \mu$ wide, are present. The Falkland Islands gathering, which are mostly on twigs and not on leaves, agrees well with this, but shows the velvety growth in better condition (perhaps owing to the moist climate), a fine pile of nearly black hyphæ, composed of cells of greatly varying length ($15\text{–}40\ \mu$), extending over several inches. No fruits occur, but young stages of an *Atichia* (*q. v.*) are discernible amongst the filaments.

EUROTIUM HERBARIORUM, *Link, Sp. Pl.* i. 79.

W. Falklands, *Vallentin.*

DISTRIB. Cosmopolitan.

In the Falkland Islands, as elsewhere, this fungus frequently develops on herbarium specimens.

ATICHIA sp. (= *Seuratia*, Pat.).

W. Falklands; on *Baccharis magellanica*, Roy Cove, *Vallentin.*

This peculiar gelatinous genus has until recently been so little known that

the occurrence even of immature and sterile specimens in the Falklands is worthy of record. In a recent number of the 'Kew Bulletin' (1914, pp. 55–63) I have dealt with the genus in full, and given a revision of all known species; from this it will be seen that a species (possibly identical with that collected by Mrs. Vallentin) occurs in Southern Chile.

CHÆTOMIUM BACIDIÆ, *Darb. Lich. Swed. Ant. Exped.* p. 18, nomen nudum.

E. Falklands; Port Louis, on *Bacidia tuberculata*, Skottsberg.

DISTRIB. Falkland Islands.

Apparently a *nomen nudum.*

SPHÆRELLA POLYGONORUM, *Sacc. Syll.* i. p. 512. *Depazea Polygonorum*, Crié, Sur les *Depazea*, p. 41, tab. 8.

E. Falklands; on *Rumex Acetosella*, d'Urville, *teste* Crié.

DISTRIB. Europe.

PLEOSPORA HERBARUM, *Rabenh. Herb. Myc.* ed. ii. p. 547.

E. Falklands; on *Senecio candicans*, d'Urville, *teste* Crié.

DISTRIB. Cosmopolitan.

CORDYCEPS MILITARIS, *Link, Handb.* iii. p. 347.

W. Falklands; at the foot of Mount Cook, Roy Cove, *Vallentin*, 23.

DISTRIB. Europe, North America, Asia (?).

An interesting addition to the flora. After careful searching, Mrs. Vallentin succeeded in finding a number of specimens, all during the month of July. They are rather small, and the ascigerous portion is sometimes flattened; but in essential characters they agree with European specimens. The pupæ were obtained and have been submitted to the British Museum authorities, who state that they are those of one of the Hepialidæ.

PLICARIA LEIOCARPA, *Boud. Hist. et Class. des Disc. d'Eur.* p. 50; *Icon. Mycol.* ii. pl. 304. *Peziza leiocarpa*, Currey, in Trans. Linn. Soc. xxiv. (1864) p. 493.

W. Falklands; apparently on burnt ground, *Vallentin*, 22.

DISTRIB. Europe.

The species agrees precisely, as far as can be seen, with European material. The type-specimens are at Kew, but authentic material was liberally distributed by Currey and specimens were sent out by Rabenhorst ('Fungi Europæi,' no. 622). Monsieur Boudier has recently redescribed and figured the plant in his magnificent 'Icones.'

CILIARIA KERGUELENSIS, *Cotton*, comb. nov. *Peziza kerguelensis*, Berk. in Hook. f. Fl. Ant. ii. p. 451. *Lachnea kerguelensis*, Sacc. Syll. viii. p. 176.

W. Falklands; Byron Sound, *Vallentin*, 43.

DISTRIB. Fuegia, Falkland Islands, Kerguelen.

This species is probably widely spread in the Antarctic. The Falkland Islands specimens agree well with Hooker's Kerguelen material in the Kew herbarium, and there can be no doubt but that it is the same plant. In Kerguelen it grew on bare boggy earth near the sea, and Mrs. Vallentin's specimens occurred on the roots and stems of *Gunnera misandra* at the margins of a lagoon, and were sometimes under water owing to heavy rains.

L. kerguelensis is closely allied to *Ciliaria scutellata*, Quél., with which it agrees in its aquatic tendencies, but it differs, as Berkeley originally stated, in its broader spores and larger size. It was also collected by Hooker at Cape Horn and has been recorded from New Zealand, but the Kew examples of Berggren's New Zealand specimens have decidedly larger spores.

An enlarged and revised description based on Mrs. Vallentin's drawings and formalin material is appended.

Apothecia 1–1·5 cm., sessile, flattened, bright vermilion, beset with short, brown, pointed hairs. Excipulum rather thin, composed of large polygonal cells, bearing rhizoidal filaments and a few hairs below and passing into a subhymenial layer above, which is composed of loosely interwoven hyphæ 10–15 μ diam. Marginal hairs brown, septate or almost aseptate, pointed, rather flaccid, 400–700 μ long. Paraphyses slender, septate, branched, apices clavate, 8–12 μ thick. Asci rather long, cylindrical, 220–240 μ long, 18–20 μ wide. Spores hyaline, smooth, granular, $17–22 \times 13–17$ μ.

CHEILYMENIA STERCOREA, *Boud. Icon. Mycol.* ii. pl. 384. *Peziza stercorea*, Pers. Obs. ii. p. 89; Berk. in Hook. f. Fl. Ant. ii. p. 451.

E. Falklands; Port Louis, *Hooker*. W. Falklands; Roy Cove, *Vallentin*, 31.

DISTRIB. Probably cosmopolitan.

Any doubt that there might have been as to the correctness of Berkeley's Falkland Islands record is placed beyond dispute by the present material. It agrees precisely with British specimens and also with Boudier's figure (*l. c.*), except that the asci are slightly longer. Spegazzini notes that the species is exceedingly common on cow- and horse-dung in Fuegia ('87, p. 124).

BULGARIA ARENARIA, *Lév. in Ann. Sci. Nat.* sér. 3, v. (1846) p. 253. *Lycoperdon arenarium*, Pers. in Freycinet, Voy. p. 179, tab. 1. figs. 1–4.

E. Falklands, *Gaudichaud*.

DISTRIB. Falkland Islands.

Persoon described this plant as a Puffball, but an authentic fragment was examined by Léveillé, who found asci present and referred it to the genus

Bulgaria. Hariot was unable to procure specimens for re-examination, and the plant, though said by Gaudichaud to be plentiful on the sand-dunes in March and April, has not since been met with.

MORCHELLA SEMILIBERA, *DC. Fl. Fr.* ii. p. 212; *Berk. in Hook. f. Fl. Ant.* ii. p. 451.

E. Falklands, *Hooker.*

DISTRIB. N. Europe, N. America.

The specimen is not to be found at Kew, and Berkeley's remarks (Fl. Ant. ii. p. 451) show that the record rests upon a very slender foundation.

PHOMA CHILIOTRICHI, *Cotton*, sp. nov.

Perithecia sparsa, minuta, globosa, 130–170 μ diam., primum epidermate tecta, demum erumpentia, in tomento plantæ nutricæ nidulanta. Sporæ 2-guttulatæ, ellipsoideæ, utrique rotundatæ, 7–8 × 3 μ hyalinæ.

W. Falklands; in receptaculis *Chiliotrichi amelloidei.* Roy Cove, *Vallentin*, 59.

CONIOTHYRIUM CHILIOTRICHI, *Cotton*, sp. nov.

Perithecia sparsa vel laxe aggregata, leviter papillata, subglobosa, 400–500 μ diam., primum epidermate tecta, demum erumpentia, in tomento plantæ nutricæ nidulanta. Sporæ numerosissimæ, eguttulatæ, ellipsoideo-globosæ, 10–12 × 8–10 μ, olivaceo-fuscæ.

W. Falklands; in receptaculis *Chiliotrichi amelloidei.* Roy Cove, *Vallentin*, 57.

C. BACCHARIS-MAGELLANICÆ, *Cotton*, sp. nov.

Perithecia sparsa, vix papillata, subglobosa, minuta, 100–120 μ diam., primum epidermate tecta demum erumpentia. Sporæ numerosissimæ, eguttulatæ, subglobosæ, minutissimæ, 3–3·5 μ, hyalinæ.

W. Falklands; in foliis *Baccharis magellanicæ.* Roy Cove, *Vallentin*, 61.

DILOPHOSPORA GRAMINIS, *Desm. in Ann. Sci. Nat.* sér. 2, xiv. (1838) p. 6.

E. Falklands; on Gramineæ, *d'Urville*, teste *Crié.*

DISTRIB. Europe.

LEPTOTHYRIUM DECIPIENS, *Berk. in Hook. f. Fl. Ant.* ii. p. 449.

E. Falklands; on *Roskowia grandiflora*, Hooker.

DISTRIB. Falkland Islands.

CLASTEROSPORUM ASCENDENS, *Sacc. Syll. Fung.* iv. p. 394. *Sporodesmium ascendens*, Berk. in Ann. Nat. Hist. iv. (1840) p. 292; Hook. f. Fl. Ant. ii. p. 450.

E. Falklands, *Darwin.*

DISTRIB. Falkland Islands.

The original specimen of this is not to be found at Kew.

LEPIOTA GRANULOSA, *Quél. Ench. Fung.* p. 7.
W. Falklands, June 1910, *Vallentin*, 13.
DISTRIB. Europe.

Excellent material in spirit was forwarded. The specimens are somewhat darker than usual, but otherwise they agree well both in external and in microscopic characters.

MYCENA POLYGRAMMA, *Quél. Ench. Fung.* p. 36.
W. Falklands, April 1911, *Vallentin*, 51.
DISTRIB. Europe.

As this fungus is usually found in connection with logs and stumps, its presence in the Falklands was hardly expected. Mrs. Vallentin's drawings clearly recalled *M. polygramma* or the allied *M. galericulata*, and it is by no means impossible that such fungi exist in the islands upon buried wood or branches of shrubs. The striate stem and pale margin point to *M. polygramma* rather than to *M. galericulata*, and the 4-spored basidia confirm this affinity, since, as Mr. Carleton Rea kindly informed me, the basidia in *M. galericulata* are bisporous.

NAUCORIA GLEBARUM, *Cooke, MS.* *Agaricus Glebarum*, Berk. in Hook. f. Fl. Ant. ii. p. 447.
E. Falklands; on *Bolax* (=*Azorella*) *glebaria*, Berkeley Sound, *Hooker*.
DISTRIB. Falkland Islands, Kerguelen.

A very doubtful plant. Cooke has referred it, in an MS. note at Kew, to *Naucaria*; the spores, which agree with those of that genus, measure $8 \times 4\ \mu$.

GALERA EXQUISITA, *Cotton*, comb. nov. *Agaricus exquisitus*, Berk. in Hook. f. Fl. Ant. ii. p. 447 (not Vitt. Maug. tab. 18).
E. Falklands; on *Chiliotrichum amelloideum*, Port Louis, *Hooker*.
DISTRIB. Falkland Islands.

From the dried specimens, this would appear to be an exceedingly small and slender *Galera*. Unless a species specially connected with *Chiliotrichum* be discovered, it will, as is the case with so many of the early-described Agarics, probably remain unknown.

AGARICUS CAMPESTRIS, *Linn. Fl. Suec.* ed. 2, p. 442, no. 1203.
W. Falklands; Byron Sound, Roy Cove, Carcass Island, *Vallentin*.
DISTRIB. All continents.

The ordinary Mushroom is frequent in the Falklands, where it is collected and eaten. Mrs. Vallentin notes that is very common in the short grass along the banks of Byron Sound, and that during February it is plentiful at Roy Cove.

STROPHARIA SEMIGLOBATA, *Fr. Hym. Eur.* p. 287.

W. Falklands; on cow-dung, May 1910, *Vallentin*, 6, 15, 25, 28, 34.

DISTRIB. Probably cosmopolitan.

The well-known *Stropharia semiglobata* is evidently a common fungus in the Falklands, several tubes collected on various occasions being forwarded. In one gathering (no. 6) the specimens were so large as to render doubtful their identity with the true *S. semiglobata*. On this account a somewhat detailed study of fresh British specimens was undertaken, the size of the spores, together with other microscopic characters, being specially noted. The results with regard to spore-variability have already been published (see Trans. Brit. Myc. Soc. 1913, pp. 298–300). The Falkland Islands specimens agreed exactly in microscopic characters with the English, and the two plants are clearly identical, the large size attained by some of Mrs. Vallentin's specimens being equalled occasionally in English gatherings.

COPRINUS RADIATUS, *Fr. Syst. Myc.* p. 313. *C. floscula*, Berk. in Hook. f. Fl. Ant. ii. p. 448, tab. 162. fig. 2.

E. Falklands; Berkeley Sound, *Hooker*. W. Falklands; Roy Cove, *Vallentin*.

DISTRIB. Europe, America (probably cosmopolitan).

There is no type of *C. floscula* in existence, but Berkeley's original drawings are at Kew. These seemed so clearly to portray *C. radiatus*, one of the commonest dung-fungi in Europe, that I sent copies of the drawings and descriptions to Prof. A. H. R. Buller for confirmation. Prof. Buller replied that *Coprini* are well-known to be widely distributed, and that he saw "no ground whatever for making it a distinct species."

PANÆOLUS PAPILIONACEUS, *Quél. Myc. Fr.* p. 55; *Pers. in Freycinet, Voyage*, p. 168.

E. Falklands, *Gaudichaud* (teste *Persoon*).

DISTRIB. Probably cosmopolitan.

PSATHYRELLA FALKLANDICA, *Cotton*, sp. nov.

Pileus tenuis, glaber, e campanulato usque planus, subumbonatus, 3–4 cm. diam., margine striato interdum subrepando; color roseo-griseus, versus umbonem flavus. Stipes equalis, subcavus, fibrillosus, glabrescens, 5–6 cm. longus, 2–3 mm. crassus, stramineus. Lamellæ adnatæ, confertæ, 4–5 mm. latæ, griseo-brunneæ, margine albido. Cystidia numerosa, hyalina, ventricosa, lævia, apice plerumque bi-trifurcata, 70–90 × 14–17 μ. Sporæ ellipsoidæ, purpureo-brunneæ, 9–11 × 4·5–5 μ.

Ab *P. atomata*, stipite stramineo, cystidiis trifurcatis distinguenda.

W. Falklands, *Vallentin*, 5.

The present very pretty species closely resembles *P. atomata*, having the

same pinkish-yellow pileus and general appearance. Mrs. Vallentin notes that it has a yellowish stem, and a further difference from that species is found in the almost constantly present prongs at the apex of the cystidia. The prongs vary from 5–10 μ long, and have not been observed as regularly present in any other species of *Psathyrella* which I have been able to examine.

CYSTOPUS CANDIDUS, *Lév. in Ann. Sci. Nat.* sér. 3, viii. (1847) p. 371.
Uredo candida, Pers., Berk. in Hook. f. Fl. Ant. ii. p. 451.

E. Falklands; on *Arabis macloviana*, Sulivan, d'Urville (*teste* Crié).

DISTRIB. Probably cosmopolitan.

Hooker's specimen, received from Captain Sulivan, has been re-examined, and no difference can be detected between it and common European species. The plant has also been recorded from various parts of the American continent as well as from Africa, and it is probably cosmopolitan. Massee remarks:—"The Kerguelen Land Cabbage (*Pringlea antiscorbutica*), although exempt from the fungus (*C. candidus*) in its native land, could not be kept in cultivation at Kew owing to attacks of this parasite" ('Mildews, Rust, and Smuts,' 1913, p. 11).

PUCCINIA VIOLÆ, *DC. Fl. Fr.* vi. p. 62.

E. Falklands; on *Viola maculata*, Port Stanley, *A. W. Hill.* W. Falklands, *Vallentin.*

DISTRIB. All continents except Australia.

Æcidial stage only. Several species of Uredineæ are known on *Viola*; and I am indebted to Mr. W. B. Grove for confirming the identification of this specimen, and also for critical advice on the three following species.

ÆCIDIUM PRATIÆ, *Speg. Fungi Fuegiani*, p. 53. no. 147.

E. Falklands; Port Stanley, *A. W. Hill.* W. Falklands, *Vallentin.*

DISTRIB. Staten Island, Falkland Islands.

A small number of the æcidia of this fungus, discovered by Spegazzini on Staten Island, were detected on the material of *Pratia repens* collected both by Mrs. Vallentin and Mr. Hill.

UREDO CHILIOTRICHI, *Cotton*, sp. nov.

Sori hypophylli, in greges rotundatas 3–4 diam. collecti, in tomento plantæ nutricæ plus minusve nidulantes. Uredosporæ longe pedicellatæ, flavescentes, globosæ vel ovatæ, 25–30 × 18–22 μ, echinulatæ.

In foliis *Chiliotrichi amelloidei*. Roy Cove, Shallow Bay, Saunders Island, *Vallentin*, 58.

No rust-fungus has previously been described as occurring on *Chiliotrichum*, which is a composite allied to *Olearia*, and confined in its distribution to the southern part of South America.

PHRAGMIDIUM RUBI-GEOIDIS, *Cotton*, sp. nov. *P. incrassatum*, Crié in Compt. Rend. lxxxvii. (1878) p. 532 (*non* Link).

Uredosori epiphylli, congesti, minuti, 0·3–0·5 mm. diam., interdum confluentes, bullati, aurantiaco-flavi, profunde immersi dein excidentes. Sporæ ovatæ vel oblongæ, 15–25 x 12–15 μ, flavidæ, basi excepta acute echinulatæ, aparaphysatæ.

In foliis *Rubi geoidis*, Roy Cove, *Vallentin*, 60.

Crié ('78) recorded a *Phragmidium* on *R. geoides*, referring it to *P. incrassatum*, Link (=*P. Rubi*, Wint.). Since that date our knowledge of the Uredineæ has greatly increased, and it is evident that the Falkland Islands species differs from the true *P. Rubi* if only in the smaller spores. Mr. Grove drew my attention to unusually bullate sori and the absence of clavate paraphyses, which are so marked a feature in the uredosori of most species of *Phragmidium*. The sori penetrate the whole depth of the mesophyll, and at length drop out, leaving a deep cavity. *R. geoides* occurs only in Fuegia and the Falklands.

? TRIPHRAGMIUM ULMARIÆ, *Wint. Pilze*, p. 225.

E. Falklands ; on *Acæna ascendens*, d'Urville, *teste* Crié.

DISTRIB. N. Europe, Siberia, Japan, N. America.

As has been the case with the last plant, further investigation will probably show that the rust-fungus on *Acæna ascendens* is a distinct and new species.

LYCOPERDON CÆLATUM, *Bull. Champ.* p. 130, tab. 430.

W. Falklands ; Shallow Bay, *Vallentin*, 46.

DISTRIB. Europe, N. and S. America, New Zealand.

For assistance with this and the following species I am indebted to Mr. C. G. Lloyd. He informs me that the photograph and spores indicate that specimen 46 is referable to *L. cælatum*, though it differs from the usual form in the absence of stalk. The single Hooker specimen referred by Berkeley to this species was wrongly named, but is now indeterminable.

L. GIGANTEUM, *Batsch, Elench.* fig. 165.

W. Falklands ; Shallow Bay, *Vallentin*, 45 & 46.

DISTRIB. Europe, N. America, Australia.

Photographs and specimens leave no doubt as to the identity of this. Mrs. Vallentin notes that the plants sometimes grow to an immense size, one specimen measuring 3 feet 10 inches in circumference. The capillitium is about 10 μ thick, and the spores smooth, olive, globose, and 4 μ diam.

L. LILACINUM, *Speg. Fung. Arg.* p. 1. no. 110.

W. Falklands ; Roy Cove, *Vallentin*, 37.

DISTRIB. Southern Europe, N. and S. America, Africa, Japan.

A fine though rather old specimen of this distinct and widely distributed species. The plant is common in South America, and often grows to a large size.

SPECIES EXCLUDENDÆ.

POLYPORUS VERSICOLOR, *Fr.*, *Berk. in Hook. f. Fl. Ant.* ii. p. 448.

This was found on imported timber, and cannot be considered as belonging to the flora.

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EXPLANATION OF THE PLATES.

PLATE 4.

Fig. 1. *Durvillea Harveyi*, Hook., exposed on rocks at low-water line. The ball and socket-like holdfasts are visible in the specimens in the foreground to the left.

2. *Durvillea* and *Lessonia* Association. Growing in fully exposed localities and just emerging at low-water.

PLATE 5.

Chordaria linearis, Cotton, comb. nov. Dried specimen, about ¾ natural size.

Plate 6.

Fig. 1. *Endoderma maculans*, Cotton, sp. nov. Surface view, showing filaments growing directly across the cells of *Nitophyllum*, and the commencement of the formation of pseudoparenchymatous tissue. (× 200.)

2. Ditto. Pseudoparenchymatous tissue with ripe sporangia and also those which have already discharged their spores. (× 400.)

3. *Chordaria linearis*, Cotton, comb. nov. Transverse section of a rather young branch with ripe sporangia. (× 400.)

4. Ditto. Longitudinal section of a somewhat older branch, showing elongation of assimilating filaments and swollen terminal cells. (× 400.)

Plate 7.

Phyllophora cuneifolia, Hook. et Harv. One of Hooker's original Falkland Islands specimens now at Kew (nat. size). In other specimens the segments are more broadly cuneate.

Plate 8.

Fig. 1. *Pteridium Bertrandii*, Cotton, sp. nov. Portion of a large female plant bearing cystocarps.

2. Do. Fragment of a tetrasporic plant showing disposition of tetraspores on either side of the midrib.

3. Do. Fragment of a male plant with antheridial patches (not visible in the photograph) in the young segments. (All nat. size.)

Plate 9.

Fig. 1. *Lithothamnium Patena*, Heydr. Vertical section of thallus showing concentric arrangement of cells of the hypothallus.

2. *Lithothamnium neglectum*, Fosl. Cellular filaments of hypothallus.

3. *Epilithon Vallentinæ*, Lemoine, sp. nov. Cellular filaments seen from above.

4. Do. Rather small specimens on the Red alga *Glossopteris Lyallii*, J. Ag. (Nat. size.)

Plate 10.

Fig. 1. *Pseudolithophyllum discoideum*, Lemoine. Young crusts on a limpet-shell.

2. Do. Older crust showing the conceptacles, visible as minute points, over the whole surface of the alga.

Figs. 3–6. *Lithothamnion neglectum*, Fosl., showing the different forms presented by the encrusting thallus. Figs. 3 and 4. Two of the commonest and most characteristic forms. Fig. 5. Crusts growing irregularly one above the other. Fig. 6. The right top corner shows characteristic young thalli, whilst the rest of the shell is covered by a single large adhering crust. (All nat. size.)

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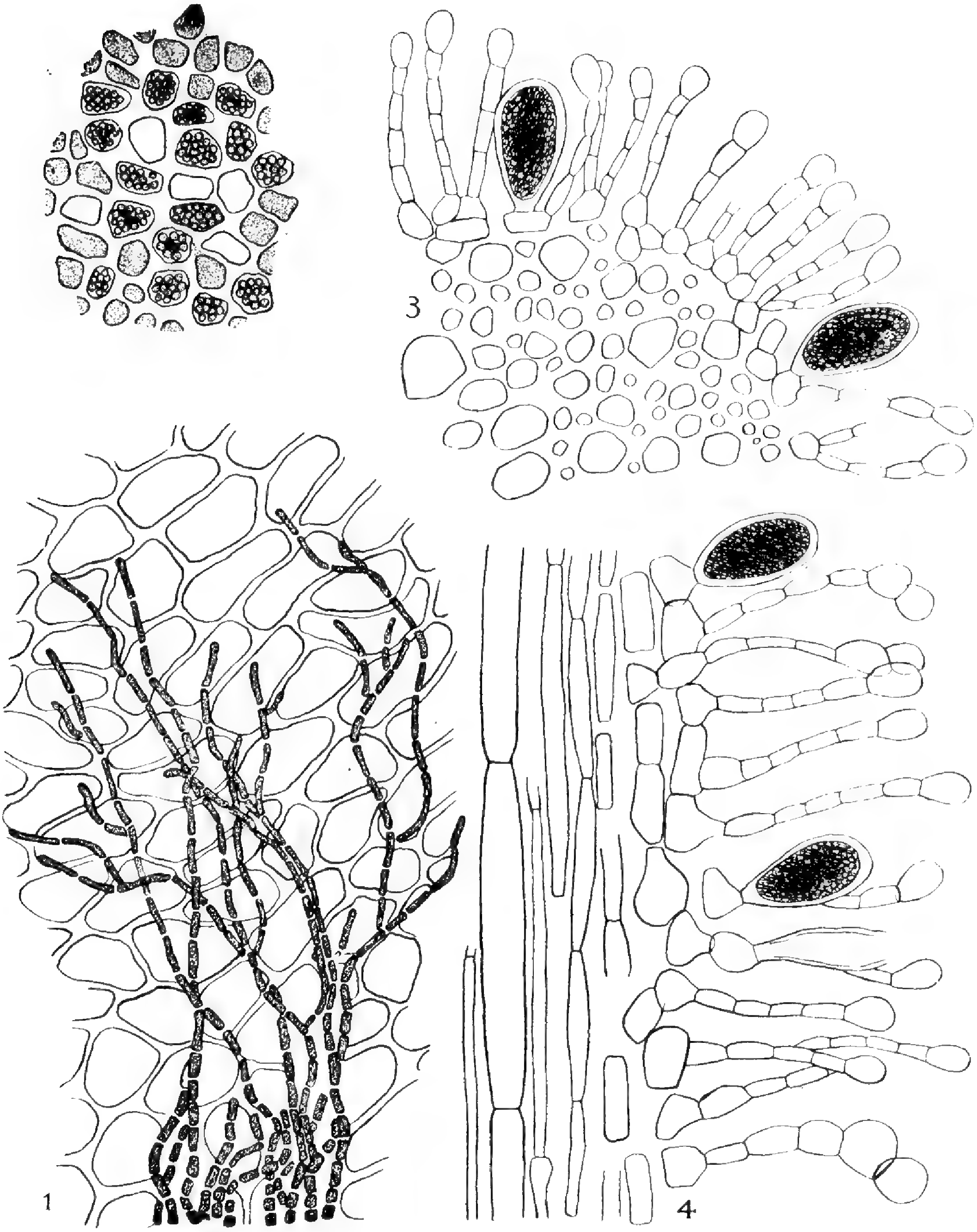

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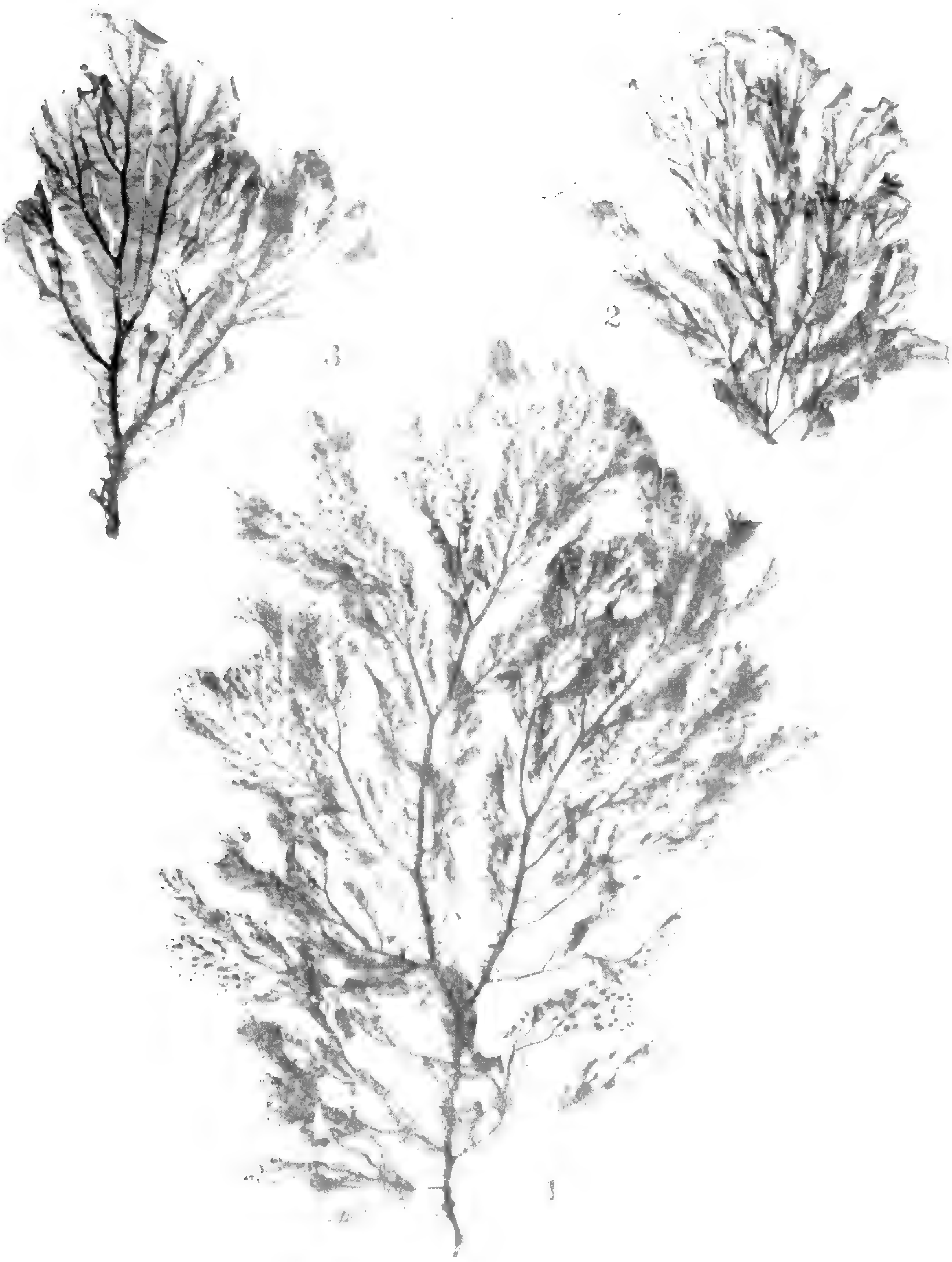

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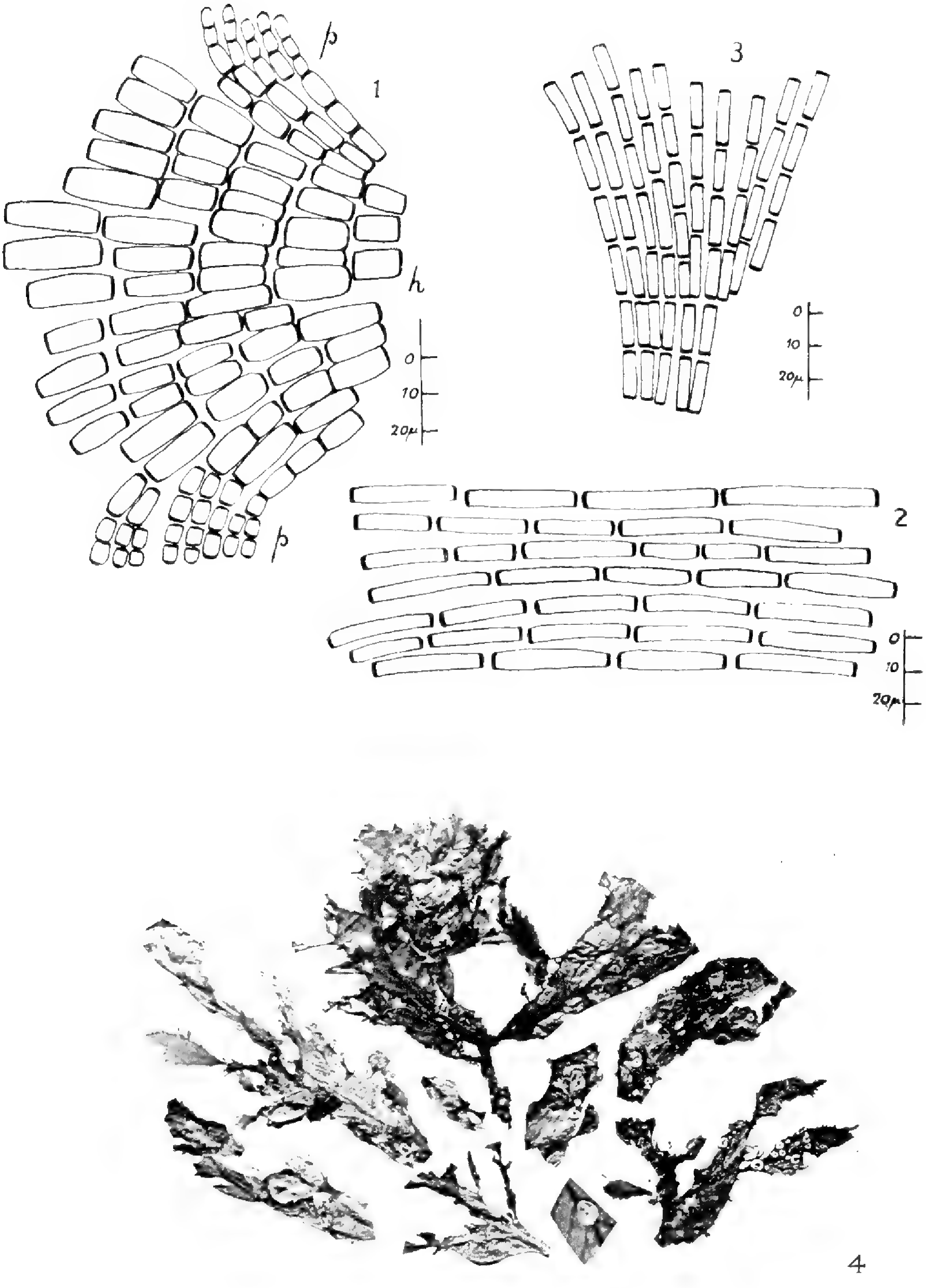

FALKLAND ISLANDS ALGÆ.

JOURN. LINN. SOC., BOT. VOL. XLIII. PL. 10.

FALKLAND ISLANDS ALGÆ.

The Structure and History of Plav: the Floating Fen of the Delta of the Danube. By Marietta Pallis. (Communicated by Prof. A. C. Seward, F.R.S., F.L.S.)

(Plates **11–25**, and 1 Text-figure.)

[Read 16th December, 1915.]

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Part I.

General Introduction.

The *Plav** of Rumania, the subject of the present paper, is a floating fen formed almost entirely of living reed, *Phragmites communis*, Trin.,

* "Plav" is the name given by the fishermen of the delta to the floating fen of that region. It is a Russian word and signifies the floating thing or floating stuff.

The languages most in use in the delta are Rumanian, Little Russian, and Greek. Amongst the Rumanian subjects in the delta (besides the Rumanians themselves) are Little Russians, Lipovans or Skoptsi (see article "Skoptsi," Encycl. Brit.), Greeks, Tartars, Gypsies, Jews, etc. It is not at all unusual for fishermen and small tradesmen to speak Rumanian, Russian, and Greek.

The pronunciation, where necessary, of all foreign words will be put in brackets in the text.

β. flavescens, Gren. & Godr.* In structure it is closely related to the fens of East Anglia, which in their early stages are usually formed of reed, *Phragmites communis*, Trin. (see Pl. **24**). In Rumania, Plav is practically confined to the delta of the Danube, where its distribution is wide though sporadic.

It has two well-marked portions, an aquatic and an aerial. The aquatic portion consists of interlaced reed-rhizomes, closely bound together by the numerous branched water-roots of the reed (see p. 250, and Pls. **11–16**), which retain much soil, and thus completely fill the interstices between the rhizomes. Hence there results a compact raft-like structure, the general surface of which projects about 4 cm. (about $1\frac{1}{2}$ inches) above the surface of the water, and measures from about 0·8 m. to about 2 m. (about 2 feet 8 inches to about 6 feet $6\frac{3}{4}$ inches) in thickness. From this raft rises a thicket of reed (see Pls. **18–20**), formed of the aerial continuations of the reed-rhizomes, that is, both of sterile leaf-bearing and flower-bearing branches. The flower-bearing extremities often measure as much as 5·15 m. (about 17 feet), and the total length of the shoot, viz. vertical rhizome plus aerial extremity, sometimes reaches a length of 7·15 m. (about 23 feet 6 inches).

The areas covered by Plav are not in general great, and owing to the dense and tall growth of the reed cannot easily be estimated. I have walked over many but have, with a single exception †, been unable to keep one direction for more than about 10 minutes, and I have usually encountered a break in the continuity of the Plav very much sooner. Measurements of Plavs are much to be desired (see p. 268).

Plav was first described by Dr. Gr. Antipa, the Director of the Natural History Museum of Bucharest and Inspector-General for the Ministry of Agriculture and the Domains ‡, in a work published at Bucharest in 1910 §. Dr. Antipa's description of Plav is short—and necessarily so—since the

* The nomenclature of the Rumanian plants is after D. Grecescu, "Conspectul Florei României," Bucharest, 1898. I have preserved the exsiccata used for the determinations.

† The exception is a Plav which according to the fishermen extends for several kilometres along the edge of Lake Lumina (see map and Pl. **20**. fig. 1). This Plav was reported to me as the largest, and it was certainly much the largest that I examined. After half an hour's walk I had found no change in its structure, and therefore turned back as the time at my disposal was short. Long as this Plav is, however, it is but a mere strip, roughly about 36 metres (about 39 yards) in width, on the *gârla* (girla: water-channel) side; it lies close behind the reed-swamp which at present abuts on Lake Lumina. I have not seen any Plav with both length and breadth great. Walking over Plav is naturally laborious, though experience teaches how it can be done without inordinate loss of time.

‡ It was as Director of the State Fisheries, a branch of the Agricultural Service, that Dr. Antipa became acquainted with Plav.

§ Antipa, Gr., "Das Überschwemmungsgebiet der Unteren Donau," Bucharest, 1912; a reprint in German from the "Anuarul Institutului Geologic al României," vol. iv. 1910.

main theme of his book is the economic development of the flood-plain and delta of the Danube in Rumania. His chief observations on Plav, and deductions therefrom, I quote on pp. 241–246.

My acquaintance with Plav dates from September 1912, when I went to Rumania to study the aquatic vegetation of the Danube valley and delta. I had for some years past been working at the vegetation of the Norfolk Broads *, and it was with the object of gaining, for comparative purposes, some knowledge of similar localities and their vegetation that I decided to visit the Danube in Rumania, where it seemed to me probable that the most primitive aquatic vegetation in Europe would be found. From September 20th to October 22nd, therefore, I travelled through a great portion of the Rumanian *Balta* † (the inundation district of the Danube in Rumania), both in the region of the high floods and in the delta, the region of the low floods. In the former region my centres were Gostinu [Gostin], near Giurgiu, Cernavoda, the Balta of Brăila and Tulcea. I crossed the delta almost entirely by water, from north to south, and also walked and drove with ox and horse along most of the shore of the Black Sea from Portiţa [Portitsa] near Lake Razim (see map), the southernmost part of the delta, to the Chilia mouth of the Danube ‡, the northernmost part of the delta in Rumania. In this way I got a general idea of the vegetation of the river valley and delta, and also saw Plav. With the express purpose of making a special study of Plav, I returned to the delta on September 3rd, 1913, and settled at the little Kirhana (fish-salting station) of Roşuleţ [Roshulets], where I remained until October 11th. The results of my investigations on Plav are published here.

The research was carried on with simple implements, chiefly with the *rizak*, a two-edged knife with a wooden handle about 2·5 m. (about 8 feet 3 inches) long, used by the local fishermen for cutting Plav (see Pl. **18.** fig. 2 & Pl. **20**); some pointed bamboos about 3·5 m. (about 11 feet 6 inches) in length for sounding purposes; a few wooden folding-rules 2 m. (6 feet 6¾ inches) long for measuring out quadrats §; a pair of small millimetre callipers for measuring the thickness of reed-rhizomes etc.; and a spring-balance weighing up to 56 lbs.‖ (25·4 kilogr.) and graduated to ½ lb. (0·226 kilogr.), for weighing sheaves of cut reed.

* See chapter X. of "Types of British Vegetation," edited by A. G. Tansley. Cambridge, 1911.

† From Sept. 9th to Sept. 20th, I took short excursions in the Rumanian Carpathians, the plain region north of Bucharest and the steppe near Faurei.

‡ In 1913 I crossed the Chilia chatal (fork) of the Danube at Periprava and spent three days on the Russian side of the river at Vâlcov. I thus also saw something of the Russian portion of the delta.

§ See Clements, E. F., "Research Methods in Ecology." Lincoln, Nebraska, 1905.

‖ It is my practice to give the measure which was actually used first, and its equivalent after it in brackets.

On my first journey Dr. Antipa gave me letters to the local officials of the Rumanian State Fisheries, who received me most kindly, even providing me in many cases with men, boats and ox-carts, and gave me the hospitality of the houses of the Fisheries' Service. In the delta the Fisheries' revisor (Superintendent), Mr. Zvoneski, accompanied me for about three weeks and made all necessary arrangements. On my second visit Dr. Antipa gave me a general open letter in case of need, and I engaged a boat and two fishermen *, with whom I could converse in Greek, who gave me throughout the most willing and intelligent help. I settled in a stronghold of Plav, four hours by rowing-boat from the port of Sulina, among a chain of lakes, the largest of which are Roşuleţ, Roşu [Roshu], and Lumina. The Kirhana of Roşuleţ, where I stayed, is situated on a low-lying *grind* or *gradá* [A] † (a raised place in the Balta), and consists of about a dozen small mud and straw huts belonging to the fishermen and the dressers of fish. The *grind*, which is not marked on the map, is only two or three feet above low-water level of the Danube: thus water often enters the huts during the floods, as it did during my stay in 1913.

I wish at the outset to express my thanks in particular to Dr. Antipa, and also to all the officials of the Rumanian State Fisheries, and to the local fishermen of all races, for their extreme kindness and courtesy. I also owe thanks to Colonel Sir Henry Trotter, K.C.M.G., C.B., for giving me my original letters of introduction for Rumania, and to the British Vice-Consuls at Sulina, Messrs. Marshall and Adams, to Mr. Magnussen of the European Commission, to Professor and Mrs. Murgoci, and to Messrs. Zeidel and Enculescu, of the Geological Institute of Bucharest, for many courtesies. Mr. Enculescu also named a number of plants for me. Acknowledgments to the specialists who made determinations for me follow in the Appendix.

To Dr. Antipa I am specially indebted not only for personal kindness but also for much assistance derived from his book ‡, which he sent me before my departure from England; in fact I am indebted almost entirely to that source for the topographical details (see pp. 237–241). I used Dr. Antipa's map showing the distribution of Plav and of the reed-thickets, which accompanied his work, throughout my travels in the delta, and now, with his permission, publish it here (see Pl. 25).

* My headman Kostantin Andrei was half Russian and half Rumanian, and my second man, Mathiouska Mikitoou, was of Russian blood. Both were Rumanian subjects.

† The capitals in square brackets refer to the Appendix.

‡ See note on p. 234, where it is quoted in full.

The Danube and the Balta in Rumania.

The river Danube is subject throughout almost its entire length to floods, which occur two or three times in the year. These floods are perhaps its most striking natural feature, and leave, in the vicinity of the river, a general impress upon organic nature. They vary in height and duration and, what is of greater importance as regards static biological conditions, they regularly vary at different places along the river-course; theoretically, therefore, a very great number of variations in the assemblage of animals and plants, in their mode of assemblage, and in their less obvious habits of life, are to be looked for along the Danube, and thus any given spot along the river is likely to exemplify a more or less definite organic entity. The Danube floods in Rumania will, however, for the purpose of this paper, only be considered where the river runs its final course and enters the tideless * Black Sea, and their significance there only in so far as they concern Plav, the subject of this paper.

The floods of the Danube occur in Rumania usually three times in the year. They follow, first, on the autumn rains, second, on the breaking up of the ice, and third, on the spring rains, and more especially on the coincident event of the melting of the snows of the Danube watershed as a whole.

The autumn floods are, for the most part, slight, seldom rising above the river-banks. The floods due to the breaking up of the ice are often considerable in magnitude, but of less regular and more local occurrence than either autumn or spring floods. They are often caused by dissimilar temperature conditions in the upper and lower courses of the river, whereby the ice breaks up earlier above than below, with the result that the ice in the lower portion of the river forms a barrier to the waters collected above. The spring floods are by far the largest, and prevail from March to the end of June, and sometimes even from February into August.

Records of the height and duration of the floods in Rumania have been kept at different places along the river-course by the European Commission † and by the Rumanian Hydrographic Service, in some cases for as long a period as thirty consecutive years. These records show that the floods differ in height at different points. Thus at Turnu Severin, which is close to the Rumanian frontier and 931 kilometres (about 578½ miles) from the port of

* According to Sir Charles Hartley the sea falls some 18 inches (about 45·7 cm.) below its mean level with violent westerly winds, and with strong easterly winds rises about 2 feet (about 0·6 m.).

See Hartley, Sir Charles A., "Description of the Delta of the Danube, and of the Works recently executed at the Sulina Mouth," Minutes of Proceedings of the Institution of Civil Engineers, vol. xxi. Session 1861–1862.

† See article "Danube" in the Encycl. Brit.

Sulina: the mean height of the spring floods is 6·05 m. (about 19 feet 10 inches) above the minimum water-level of the Danube at that point (zero on the local river flood-gauges). At Tulcea, at the apex of the delta, 72 kilometres (about 45 miles) from Sulina, it is 2·93 m. (about 9 feet 7 inches), and at Sulina itself 0·49 m. (about 1 foot 7 inches), with a maximum height of 0·81 m.* (about 2 feet 8 inches). The height of minimum water-level at these three places is, respectively, 42·13 m. (about 138 feet) above zero of the Black Sea †, 0·39 m. (about 1 foot 3 inches), and zero. Thus it will be seen that in the upper course of the river the rise of water is very much greater than in the delta.

With the comparatively low floods which prevail in the delta is connected the comparatively small amount of sediment carried into the Balta itself, that is to say beyond the immediate vicinity of the river-channels, in consequence of which the waters of the Balta remain dark and clear ‡. It is the small amount of inorganic sediment deposited in the interior of the delta that is apparently the factor which practically limits the distribution of Plav to that region as a whole; outside it Plav is merely in an incipient stage (see however, p. 245).

The pathway of the floods depends upon their magnitude in relation to the physiographic features of flood-plain and delta interposed in their way. Thus, if the flood be small or in an early stage of its rising, the waters pass inland laterally along the numerous *gârlas* which ramify through the Balta and often directly connect the Balta-lakes with the river. If, however, the flood be great, the waters do not remain confined to the channels but progressively overtop the physiographical obstacles (which they themselves for the most part have raised), such as embankments, low *grinds*, and the shoals which block the water-channels at their entrance to lake at one end and river at the other, remodel some, sweep away others, and finally mount over all but the highest eminences in the Balta §. Circulation in the Balta does not, however, proceed during flood-time only, but is practically continuous either from river to Balta or *vice versa*. The

* No official water-levels are taken in the Balta of the delta itself. In the autumn of 1913, however, when I was at the Kirhana of Roşuleţ, I daily noted the rise of the waters from about the time when they began to rise, September 6th, to October 3rd, when they ceased to rise. That autumn they reached a height of about 0·6 m. (about 2 feet).

† Zero of the Black Sea is low-water-level of the Black Sea, and is 4·88 feet (1·46 m.) below the bench-mark which was established in 1857 at the base of the large lighthouse of Sulina.

‡ The contrast between the Danube waters and the waters of the Balta is to be seen plainly on the south side of the Danube at Sulina, where a Balta stream issues. For a short distance the waters of this stream do not mingle with the grey sediment-laden waters of the Danube, but remain brown, clear, and distinct.

§ The large grinds of Letei and Caraorman (see map) in the delta are never flooded.

relation of the various Balta-lakes to the river water-supply may be given to illustrate how circulation is effected.

The Balta-lakes stand roughly in three relations to the river water-supply. The lake-bottoms are situated either above, below, or about level with the local minimum water-level of the Danube. The normal height of the water-surface of the lakes is approximately 1 m. (about 3 feet 3 inches) above the lake-bottom (Dr. Antipa's conventional lake-surface); the Danube has therefore to reach at least the height of the lake-bottom plus approximately 1 m. in order that water may pass by the *gârlas* to the lakes, and a greater height in order to flow over its own embankment and those of the lakes.

(1) Between the Rumanian frontier and the mouth of the river Prutu [Prut] near Galați [Galats], the bottoms of the lakes are about 0·8 m. to 2·41 m. (about 2 feet 7 inches to about 8 feet) above minimum water-level of the Danube, and the Danube has to rise between 4 and 4·98 m. (about 14 to 16 feet) before the waters are able to overflow the lake-embankments of that section. (2) Between the mouth of the Prutu and Tulcea the lakes are about 0·4 to 0·6 m. (about 1 foot 4 inches to 2 feet) under zero of the Danube, and the river has to rise about 2·2 m. (about 7 feet 2 inches), before it can flow over the lake-banks. (3) The delta lakes lie 1·8 to 2·75 m. (about 6 to 9 feet) under zero of the Black Sea (*i. e.* −1·8 to −2·75 m.), that is to say at least 2 to 2·2 m. (about 6 feet 6¾ inches to 7 feet 2 inches) below minimum water-level of the Danube. The river does not, however, flow over their banks until it has reached a height of about 2·78 m. (about 8 feet 9 inches) at Tulcea.

The heights of the lowest portion of the lake-banks and of the channel-shoals, as well as of the water-surface of the lake, in relation to that of the river, are factors which regulate inflow and outflow. It is, in fact, on the lesser physiographical features, such as channel-shoals, that the permanency of the Balta-lakes during low-water is often ultimately dependent. Dr. Antipa gives tables * showing the relation of the more important lakes to the river water-supply, indicating in most cases the height of the lake-bank, and also the height of the Danube at which the *gârlas* begin to function as inflow channels. Numerous diagrams in the text elucidate these relations.

The river affects not only the Balta but also the Black Sea, whereas the latter, for its part, since it is tideless, affects the river but little: only very occasionally does salt-water pass up the Danube, and then only for a short distance, whereas the waters of the Black Sea close to land are diminished in salinity and are always more or less murky with silt from the Danube. There is, in fact, a visible line of junction often as much as 12 to 14 kilo-

* See Antipa, "Das Überschwemmungsgebiet der Unteren Donau," pp. 28–31 and 36–39.

metres (about 8 to 9 miles) from land where the murky waters of the Danube meet the clear waters of the sea. An interesting indication of the diminished salinity of the Black Sea close to land is afforded by the presence of small colonies of reed actually growing in the sea itself close to Sulina; whilst the brackish-water Cirripede, *Balanus improvisus*, Darwin *, is attached to the under-water portions of the reed stems and rhizomes.

The Balta comprises all the low-lying lands in Rumania overrun by the Danube floods, namely, the reed lands, water-meadows, and lakes, both of the river-valley and of the delta, and is, except for a few eminences—some of the grinds—flooded almost every year. The total area of the Rumanian Balta is about 891,000 hectares (about 3438·7 sq. miles), about 400,000 † hectares (about 1543·75 sq. miles) of which are delta.

There is between all portions of the Balta a certain similarity, but there are also conspicuous differences. The Balta of the upper portion of the river up to Tulcea presents in many ways a sharp contrast to the delta. It is subject to high floods, a large amount of silt is annually deposited there, and there are a considerable number of temporary and shallow lakes. It is a region of willow-forest [App. B, p. 276], of pasture, of reed-thicket (see Pl. **23.** fig. 1) which is swamp during part of the year only, and of reed-swamp which is permanent the whole year round, and Plav, except in the incipient form called *Prundoae* by the fishermen (see p. 245), is absent. The delta, on the other hand, is a region of comparatively low floods, the amount of silt annually deposited in its Balta is slight; and the lakes are for the most part permanent and comparatively deep. Willow-forest and pasture are practically absent, and intermittent reed-swamp ‡ occurs only locally; it is, in fact, a primitive region almost entirely covered by permanent reed-swamp and Plav (see Map, Pl. **25**).

The average floor-level of the delta, the home of Rumanian Plav, is about 1·8 to 2·75 m. (about 6 feet to 9 feet) below low-water-level of the Black Sea, and is, except for the relief of a few embankments, shoals, and islands (the *grinds* of the fishermen), one huge sheet of water divided up into great and small lakes by the advancing reed-swamp which encroaches in many directions on the open water (see Map, Pl. **25**). The commencement of the Balta lies here just behind the narrow sand *grind* which forms the present sea-beach, and is sharply marked out by the close ranks of

* I am indebted to Dr. P. P. C. Hoek, of Haarlem, for naming the Cirripede.

† See p. 2 of Antipa, "Die Biologie des Donaudeltas und des Inundationsgebietes des Unteren Donau." Jena, 1911.

‡ The soil of the intermittent swamp of the delta differs from that of the upper portion of the river. In the delta, if the intermittent swamp is situated near the beach the soil is sandy, but if inland, at the edge of the *grinds*, the proportion of organic matter may be considerable. On the other hand, the soil of the reed-thicket of the upper portion of the river is, almost entirely, flood-deposited river-silt: that is, fine inorganic soil.

tall reed, through which, during times of flood, the waters often escape, converting sea and Balta into an almost continuous whole. The beach, which is one of the few cart-roads of the delta, is then disturbed by numerous runnels issuing from the Balta, and travellers are on these occasions compelled, in some places, to drive in the sea itself along a sand-bank under water.

Introduction to Plav.

Before proceeding with the detailed account of my work on Plav, I will quote Dr. Antipa's more important observations and conclusions concerning its structure and origin, and, since we are in some cases at variance, I will indicate briefly after each where we differ. I should like to point out that Dr. Antipa does not profess to have treated Plav exhaustively; he has, in fact, expressed the hope that some botanist or agricultural geologist will take up its study more fully than he was able to do. In his book only nine pages* are devoted to Plav, and they include figures in the text.

(1) "Die Plaur †-Decke hat eine mittlere Dicke von 0·90 m.–1 m. [2 feet 11·5 inches–3 feet 3 inches] und wird aus dicken, in einander verflochtenen und durch ihre wie Barthaare feinen Wurzeln zusammengebundenen Schilfrhizomen gebildet welche sich untereinander verfilzen und zusammen eine schwimmende ‡, mehr oder wenige kompackte Masse darstellen."

I took some forty sections through Plav and found its thickness to be between 0·8 m. and 2 m. (about 2 ft. 6 in. to 6 ft. 6¾ in.). These measurements refer only to the compact portion of the Plav; they do not include the open layer of loose hanging rootlets (see section I, Pl. **24**).

(2) "Ueber diesem schwimmenden dürren Rohr wächst einesteils grünes Schilf, das sich aus den horizontalen Rhizomen des Plaur entwickelt," etc., etc.

The aquatic portion, or rhizome, of the reed cannot be called sterile, because the aerial portion is not separate from it but is its continuation, rhizome and aerial extremity forming one shoot (see pp. 246–248 and Pl. **11**).

(3) "Am unteren Teile des 'Plaur' gehen die Schilfrhizome in Fäulnis über; da aber im Wasser nicht genügender Sauerstoff hierzu vorhanden

* Pp. 225–234, *op. cit.*

† Plaur = Plav.

‡ In proof of the floatage of Plav, Dr. Antipa adduces the fishermen's huts built on Plav, which, because the Plav floats, are more or less habitable all the year round. He also cites the abundance of wild boar (*Sus scrofa ferus*, Ball) in the lower portion of the delta, around Sulina, Chilia, and Dranov, where Plav abounds. Where Plav is scarce, as in the upper portion of the delta, though the reed occurs abundantly as a thicket, wild boar are scarce.

ist, findet kein völliges Verfaulen, sondern nur eine Art von Sapropelbildung statt, so dass ihre Haarwurzeln sich in eine schwarze fette Masse verwandeln, während die Rhizome ihre Form beibehalten, aber ein verkohltes Aussehen bekommen."

I did not find the dead rhizomes aggregated towards the lower portion of the Plav (see p. 262), nor did I find the rhizomes and rootlets transformed into a black slimy mass (see Pls. **14**, **15**, & **16**). Dead rhizomes and rootlets—more or less slimy and discoloured—occur in plenty, but distributed throughout the entire Plav-layer as well as in its lower portion. The living rhizomes which end in the tallest aerial shoots, in fact, start at the very base of the Plav (see Pls. **15** & **16**); growth must therefore be active there. Moreover, dead internodes at the base of the Plav are likely to drop off. Thus the base of the Plav is in general healthy in appearance, rather than the reverse (see Pls. **15** & **16**). I have never found rhizomes and rootlets which were dead and yet retained their shape: the resemblance which the dead bear to the living is that of a collapsed to a distended balloon. I have never seen rhizomes carbonized in appearance, whether alive or dead. The dark colour of the Plav-layer is due, not to the decomposed reed, but to the organic soil (see p. 262) which the Plav retains as would a filter (see Pls. **14–17**).

(4) "Die Rhizome des oberen Teiles des Plaur leben weiter und senden senkrecht zu ihrer Richtung, also gerade nach oben, neue Schilfhalme aus. Es kann hier beobachtet werden, wie durch das Wurzelgewebe, etwa in einer Tiefe von 40–50 cm. [about 15–20 inches], sich die Schilfhalme Raum suchen, um an die Oberfläche durchzudringen," etc.

As already remarked, the Plav-layer is alive as a whole, and since the aerial portions are the continuation of rhizomes, they cannot be said to arise at any particular depth: they do so everywhere in the Plav, at a depth which is determined by their order in the branch-system (see p. 267). All rhizomes end, will end, or have ended, in an aerial portion, whether they be primary, and therefore extend throughout the whole Plav, or branched to the 5th or 6th degree, and therefore quite short (see pp. 248 & 257, Pl. **11**).

(5) "Zwischen den die Plaurdecke bildenden Rhizomen und Wurzeln dringt oftmals das Wasser durch und gelangt bis zur Oberfläche, wo es so mehr oder weniger eine künstliche Wasserfläche bildet und dem ganzen das Aussehen eines Sumpfes gibt."

Dr. Antipa's explanation of what I will call false swamp appears to me directly to contradict the fact that Plav is a floating layer: so long as Plav remains floating, water cannot find its way between the rhizomes and rootlets and overspread its surface. Isolated pools can, however, be formed on the surface of a Plav where it is uneven and dips below the water-level. In these pools swamp-plants may grow, thus making small swamps of them. The finest

examples of this kind of "false swamp" occur round the grinds, that is to say in shallow water, where a *fixed* platform of reed, practically identical in structure with Plav, forms under water. This platform is covered by water varying in depth according to the stage of its growth and the height of the Danube, and on it aquatic plants are rooted (see section III, Pl. **24**).

(6) "Der Plaur ist in der Regel mit dem Schilfbestand von einem auf festem Ufer [grind] gewachsenen verbunden und bildet gewissermassen die Fortsetzung desselben; er erstreckt sich aber so weit in die Balta, dass wir ihn auch 10 km. [just over 6 miles] vom Grind entfernt antreffen."

Plav which is situated round the grinds is certainly joined to the shore-fringing reed, as, for instance, at Roşuleţ. Many Plavs are, however, entirely unconnected with grinds. Their source of attachment cannot therefore be shore-fringing reed. Plav is apparently attached in at least two different ways, or is possibly sometimes unattached (see p. 261).

(7) "Die vom Plaur ausgeführten Bewegungen erfolgen nur in vertikaler Richtung, so dass er sich auf- und niederbewegt je nach dem Steigen und Fallen des Wassers der Balta."

I concur with the above, unless "Schwimmende Inseln" are *small complete* Plavs, as I am inclined to believe (see below, and also p. 261).

(8) "Gefrieren zur Winterzeit die Balten ein und bilden sich dann lange Spalten im Eise, so bricht mit diesem auch der Plaur, als ob er mit dem Messer entzwei geschitten worden wäre; auf diese Weise trennen sich vom Hauptplaur grosse Stücke ab, die fortfahren zu schwimmen und zu wachsen, und sogenannte 'Schwimmende Inseln' (in den Seen von der Leteainsel u. s. w. auch '*Prundoae*' genannt) bilden. Die Seen von Matiţa (Matitsa), Obretinul, Mazilul sind voll solcher schwimmender Inseln," etc.

It does not seem to me likely that "Schwimmende Inseln" are, as a rule at any rate, produced as described by Dr. Antipa. Their appearance suggests to me rather that they *originate as small independent Plavs*, and not as *cut off pieces of Plav*. Those I saw were not angular in shape, but more or less round or oval (see Pl. **21**); I have not, however, been in the delta in the winter, and can therefore make no direct assertion as to their origin (see p. 261).

(9) "Der Plaur, d. h. diese schwimmenden Formation des *Phragmites communis*, bildet sich nur in tiefen Seen und besonders in jenen, wo kein trübes sondern klares Wasser ist, ... Auf festem Grind bildet sich kein Plaur, sondern nur auf sumpfigen Grunde, d. h. nur auf dem Grund, der mit einem feinem, schwarzen, weichen Schlamm bedeckt ist und der sich nur in Seen mit klarem, abgeklärtem und in Folge der Verwesung von Wasserpflanzen mit wenig Sauerstoff versehenem Wasser findet, ein Schlamm von der Beschaffenheit desjenigen, den Potonié Sapropel genannt hat."

On the whole, I agree with Dr. Antipa that the factors cited above are important in relation to Plav-formation. I do not, however, agree that

a soft bottom is in itself essential to Plav formation, though as a matter of fact, by the time the reed has become detached, *i. e.* Plav, soft fluvio-lacustrine ooze (ooze with a considerable proportion of organic matter) does nearly always cover the hard bottom.

(10) "Das Uferschilf bringt unter solchen Bedingungen [viz. the factors just cited] horizontale Rhizome hervor, ... Diese Rhizome erzeugen in Abständen dünne Wurzeln, die in der Erde Fuss zu fassen suchen, dies aber nicht können, da der Seengrund aus jenem weichen oben erwähntem Schlamme besteht.

"Ebenso tritt es häufig ein, dass die Schilfhalme sich gegen das Wasser hin in der Richtung des Windes neigen und die sogenannten 'Legehalme' bilden, die Reissek in Ungarn zuerst beobachtet hat. Diese stehen ständig in Wasser; sind sie jung, so werden ihre Blätter rudimentär, rings um den Knoten sprossen feine und dichte Wurzeln hervor, ihre Halme wachsen mit sehr grosser Schnelligkeit und bilden Internodien von 30–40 cm. [about 12–16 inches]; dann fallen sie auf den Grund des Wassers und suchen dort festzuwurzeln, treffen aber den feinen Schlamm an, an welchem sie sich nicht ansetzen können; fassen sie aber wirklich Grund, so werden sie später, wenn das Hochwasser kommt in die Höhe gezogen und losgerissen.

"So wohl die Rhizome, wie auch diese Legehalme nähern sich einander während ihre feinen Wurzeln derart untereinander anastomosieren, dass sie eine Art Filz bilden und das Ganze auf dem Wasser schwimmt; die Samen der Landpflanzen setzen sich dann oben an, beginnen zu treiben, so dass aus der Zersetzung jeder Jahresvegetation fortgesetzt Humusschichten gebildet werden, die sich übereinander legen und den Plaur immer tiefer senken."

I do not agree with Dr. Antipa's theory of the origin of Plav, as set forth above. First, because in the sections of Plav which I examined I found no single instance of Plav constructed of horizontal rhizomes as Dr. Antipa assumes it to be and as his figures show it, but, on the contrary, found Plav to be constructed predominantly of vertical rhizomes (see Pls. **14–17**). This fact is at variance with any theory of origin from horizontal structures such as united "Legehalme" and bottom-creeping rhizomes. Second, because the "Legehalme" themselves, as I point out on pp. 249–250, do not generally arise in the same manner as do those described by Reissek * for the Danube in Austria-Hungary, where the general aquatic conditions differ markedly from those prevailing in the delta. Further, "Legehalme," such as those described by Reissek, would have to occur abundantly in the delta—which they do not—in order to give rise to a phenomenon as widespread as Plav. Thirdly, because I believe that Plav is formed in a different manner (see pp. 258–260). Incidentally it may be said, if the reed were as insecure as Dr. Antipa's description suggests, it would hardly ever be found attached

* Reissek, S. "Vegetations-Geschichte des Rohres an der Donau in Oesterreich und Ungarn." Verhandl. k.-k. zool.-bot. Ges. Wien, ix. (1859) pp. 55-74.

in the delta, since floods are so frequent; whereas, in point of fact, attached reed (reed-swamp) is far more abundant than Plav.

(11) "In weniger tiefen Seen wie z. B. in den Seen von Brăila, bildet sich der Deltaplaur nicht. Aber auch in diesen Seen gibt es eine Art schwimmenden Schilfs. Dort werden durch den Tritt des Viehs, durch Eisstoss, Gefrieren, etc., grosse Stücke alten Schilfs losgetrennt, die mit einander durch ihre Wurzeln verbunden sind. Diese Stücke schwimmen auf dem Wasser, werden vom Winde fortbewegt, und die Fischer nennen sie 'Plavie' oder 'Plaghie' an andern Orten wiederum 'Coşcove' [Coshcove], 'Cocioace' oder 'Culare'. . . . Solche kleine Inseln gibt es: bei Somova, am nördlichen Teil des Brateş (Bratish), selbst im Siutghiol bei Constantza u. s. w., die durchwegs tiefe Seen sind. Diese schwimmenden Inseln haben jedoch nichts mit dem Plaur des Deltas zu tun, der eine ganz andere Bildung ist. Es kommt allerdings vor in manchen Seen wo ähnliche natürliche Bedingungen wie im Delta sind—d. h. wo man ein ruhiges, klaares sauerstoffarmes, tiefes Wasser hat, mit einem weichschlammigen Boden, mit regelmässigen periodischen Schwankungen des Wasserspiegels etc.—dass dort das Rohr Plaurähnliche Formationen bildet. So ist es z. B. in den Seen Vederoasa, Somova etc. doch sind das nur [Formationen von] ganz kleinem Umfang aber dafür sehr interessant, denn sie zeigen uns im kleinen die Art wie die grossen Plaurbestände des Delta sich gebildet haben."

I examined some of the floating-reed of the Somova chain of lakes (near Tulcea), the "Prundoae" of the local fishermen. I detected no differences from Plav in essentials, that is to say, in structure and origin: Prundoae is merely Plav of small extent, but its soil is grey, that is to say, almost entirely inorganic *, except for the few centimetres of organic soil which are aggregated at the top of the Prundoae—the contribution of the land-plants rooted in it. The grey soil of Prundoae is readily accounted for by the fact that the Somova lakes are not in the delta and the floods are therefore much greater (see pp. 237 & 238). The waters of the Somova lakes were, at the time that I visited them (about October 18th, 1913), still grey with the fine river-borne silt which they held in suspension. To sum up, the environment in some spots outside the delta, although somewhat similar to that of the delta, differs sufficiently to prevent the frequent formation of Plav.

(12) "Im Prozesse der ständigen Umwandlung der Seen spielt der Plaur

* In the Museum of the Geological Institute of Bucharest there is a specimen of "Plav" which as regards structure and soil, though not as regards thickness—it measures only 0·5 to 0·6 m. (about 2 feet)—is an average sample of the delta Plav. The low organic contents of its soil must be connected with its place of origin—near the Dunăvăţul [Dunavatsul], one of the largest waterways of the southern portion of the delta, and as such having a fairly rapid current and therefore able to carry a considerable quantity of inorganic silt. I do not regard this specimen, which is labelled Plav, as typical delta-Plav but as Prundoae, which, as I remarked above, does not differ from Plav structurally but only in its size and in the kind of soil it holds.

sicherlich auch eine bedeutende Rolle. . . . Bei einer grossen Ueberschwemmung, wie die im Jahre 1897, bringen die Hochwasser grosse Mengen schweren Geschiebes (Sand und Schlamm) mit, setzen sie auf dem Plaur dort ab, wo er dem Ufer am nächsten ist, beschweren ihn und drücken ihn dadurch auf den Grund des Sees, der dadurch angefüllt und zum Sumpfe wird. An den im Delta gemachten Durstichen waren oft alte Plaurschichten zu sehen, die mit Sandschichten bedeckt waren, über welchen dann eine neue Schilfformation lagerte."

The gradual covering up of a Plav quite close to the grind where it is fixed must undoubtedly sometimes take place. An examination of the configuration of the ground near such a buried Plav would probably in most cases solve the above question.

General Description of Phragmites communis, *Trin.*, β. flavescens, *Gren. & Godr.**

The reed of the delta of the Danube †—viz., the reed which gives rise to Plav—differs from the reed of East Anglia (*Phragmites communis*, Trin.‡), which gives rise to fen, (1) by its larger size, (2) by the colour of its glumes, and (3) by the fact that buds are more frequent on the nodes of the aerial portion of the shoot. Yet though these two varieties differ in the above particulars, the description which follows of the delta of the Danube variety of reed applies fairly closely to the East Anglian variety as well.

When the plant is young (see p. 267) the aerial portion of its shoots is often 5·15 m.§ (about 17 feet) in length, and since the thickness of the Plav layer is often 1·5 m. (about 5 feet), the total length of the shoot is not infrequently as much as 6·7 m. (about 22 feet), whereas the shoots of the East Anglian swamp-reed, measured from the surface of the fen, very rarely reach a length of 2·5 m. (about 8 feet 3 inches), and their rhizome portion is perhaps 1 m. (about 3 feet 3 inches); viz., their total length is about 3·7 m. (about 12 feet). The glumes of the Danubian

* *Phragmites communis*, Trin., *β. flavescens*, Gren. & Godr. = *Arundo isiaca*, Sieb.

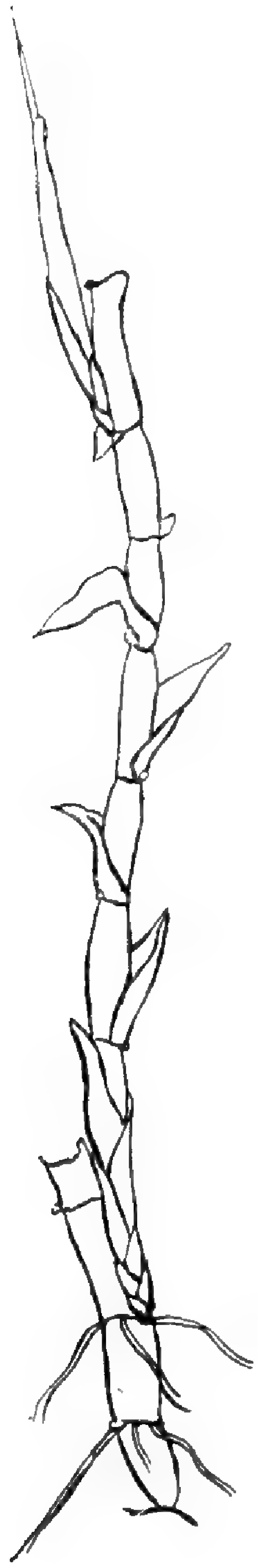
† I found the same variety of reed near Tulcea in the Somova plexus of lakes—that is to say, in the Danube above the delta. It is probably the prevalent variety in the Danube—in Rumania at any rate. Grecescu gives *Phragmites communis*, Trin. as also occurring in Rumania, but I did not find it.

I have found a giant variety of the reed, probably *P. communis*, *β. flavescens*, Gren. & Godr., also growing commonly in Epirus (around the Gulf of Arta) and in Macedonia, but had no opportunity of examining it at close quarters.

‡ I distinguish three varieties of reed in the Norfolk Broads. One of these is confined to the river Yare; another, the "Black Feather," I have seen only on the Ant; and the third is generally distributed. I hope, later on, to publish the distinguishing features of these three varieties.

§ The shoots were measured from the surface of the ground to the base of the "feather."

Text-fig. 1.



A single shoot of *Phragmites*, showing its alternately-placed scales pierced by the emerging buds.

variety are fawn, of the East Anglian purplish brown. Caryopses occur quite usually in both. I have not tested their germinating capacity.

The lower portion of the reed, the rhizome, is perennial and lives under water. Its aerial extremity, which bears the foliage leaves and flowers, lives in the air and is annual. Hence rhizomes are more numerous than living aerial extremities. The dead stems often remain standing for two years, and nearly always for one (see p. 257)

The branch-system of the reed is sympodial (see Pl. **11**). The rhizome advances for a short distance in the horizontal direction before turning upwards to the surface, and then another bud on the rhizome repeats the process. Behind the growing-point of the horizontal rhizome, rhizomes also rise to the surface immediately, and these are often branched. Thus the reed combines both the creeping and tussock mode of growth of the grasses (see Pls. **11**, **12**, & **13**).

The direction taken by the rhizome depends largely on its environment. In deep water it is much branched in the vertical direction, because the buds which occur at the nodes in the axils of the alternately-ranged sheathing-scales (see text-fig. 1), and also at the nodes of its continuation the aerial stem, develop if immersed. Hence, in deep water, where a great length of reed-stem is under water, huge stools *, consisting of numerous vertical branches, often compound to the sixth degree, are formed. The individual tussock is, in fact, a small isolated branch-system, the result of the branching of an ascending rhizome. The primary rhizome may, in fact, be regarded as the trunk, and the subsequent rhizomes arising from it as its branches (see p. 268).

These branch-systems—*i. e.*, the stools—are of course connected with each other. That the reed forms such branch-systems is evident all through its life, as the grouping of the shoots both on Plav and on fen indicates. In shallow water, on the other hand, the reed branches chiefly in the horizontal plane : hence it appears highly probable that the reed arising from one seed (see p. 252) will cover larger areas in shallow than in deep water where it branches vigorously in the vertical plane. In either case the reed fills the space under water more or less completely.

The aerial portion of the stem does not under normal circumstances branch ; to do so it must suffer injury † or immersion. It is, as it were, the

* I first noticed the stool form of the reed in 1908, in the Broads of Surlingham and Strumpshaw, in the river Yare, in Norfolk [App. C]. At the Phytogeographical Excursion in August 1911, I showed some of these stools to the assembled British and Foreign botanists, and was assured by all that they had not known of the existence of the reed-stools before (see Pl. **22**. fig. 1).

† If an aerial extremity is injured, in the delta of the Danube, one or two of the buds just below the injury develop into small ill-nurtured shoots which do not flower but which produce a few small leaves. It occasionally happens, also, that in the reed-swamps the

accident of its aerial existence that has caused it to remain simple and annual, instead of its being branched and perennial like the rhizome. Some observations were made in 1859 by Reissek* on the development which takes place in immersed portions of the aerial stem of the reed ; and he points out that an immersed reed-stem, if buried by sediment, is able, to some extent, to fulfil the office of a rhizome as regards the acquiring of fresh territory. These immersed aerial shoots he calls " Legehalme."

Reissek states in his paper that Legehalme can arise anywhere under aquatic conditions, but that they do so more readily if the bottom slopes and is pebbly, if the situation is exposed, and if the aerial portions of the reeds are weak and isolated, and the rhizomes shallow-rooted. Under the above circumstances the aerial portions of the reed-shoots bend over, as neither their structure nor their surroundings give them support, and sooner or later they are blown on to the surface of the water. These blown-over shoots, he goes on to remark, grow astonishingly fast in the water, especially if young, and often produce internodes 0·32 m. (about 1 foot) or more in length †. Gradually the Legehalme sink and attach themselves to the bottom by their roots. A temporary fall of the water favours rooting, because the Legehalme are carried down with it, and wherever a node touches the bottom, roots are produced. Pebble-banks situated at the edge of stagnant pools, and exposed by the falling of the water, are often in the autumn surrounded by Legehalme about 14 to about 16 m. (about 47 to 53 feet) in length. Their growth in length, Reissek remarks, is unquestionably aided by the slight development of the leaves, and they are of some, though slight, use as regards the horizontal advance of the reed under the conditions prevailing on the Danube near Vienna, where he worked.

In the delta of the Danube I also found Legehalme, though they were rare, but they were produced under circumstances which differed from those described by Reissek. The delta Legehalme did not arise from weak isolated blown-over shoots, but from shoots partially, or entirely, severed, owing to breakage by fishermen's boats ; also, steep slopes and pebbly reaches do not exist in the delta, nor is there a sufficient annual deposit of sediment to bury them should they sink. Moreover the water is

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aerial extremity of the shoots is broken quite close to the surface of the water, in which case the reed may become tufted near its broken apex. The larva of a small moth, whose empty pupa I found in the top joints of the reed, is often responsible for injuries to the aerial portions of the shoot. On one Plav, close to Lake Iacob, near Caraorman, a considerable proportion of the reed-shoots were injured in this way and had therefore one or two branches about 12 cm. (about 5 inches) in length near their injured apices.

* Reissek, S., in Verhandl. k.-k. zool.-bot. Ges. Wien, ix. (1859) pp. 55–74.

† The measurements are given by Reissek in Wiener Fuss. One Wiener Fuss = 0·31726 metre (a little over one English foot).

relatively deep in most places, so that they are not likely to be carried to the bottom.

In the delta, Legehalme are therefore not important, nor do I think that there is much chance of their reaching the bottom in a sufficiently healthy condition for their buds to develop. Water-logged rhizomes are, in part at least, decayed, and decay spreads to the nodes, and hence to the buds; I incline therefore to believe that in the delta practically only dead Legehalme reach the bottom. Legehalme are certainly, even under the most favourable conditions, of but slight use as regards the advance of the reed, and thus can have no connection with the building-up of Plav which is so widely distributed in the delta (see p. 244) and is moreover built up chiefly of vertical rhizomes.

The question arises here: what is the irreducible minimum of *detached* aerial shoot or of rhizome from which the reed is able to found a fresh colony; viz., how many internodes must be partially decomposed, and hence water-logged, in order to sink a given number of whole ones? *A priori* it would appear that the piece cannot possibly contain less than two absolutely healthy internodes, in which case there would be one node, and therefore one bud, removed from the areas of decay. These considerations lead me to believe that the reed does not establish itself by detached pieces—except where it is carried down quickly by the fall of the water—or, at any rate, only extremely rarely. Seed, and the vegetative multiplication of rooted reed-shoots, are, I believe, the two important methods by which it succeeds in colonizing fresh ground: obviously, experiments are desirable here.

Each succeeding vertical reed-rhizome is, as a whole, somewhat thinner and shorter than its parent (p. 267). The stems which are the finest and longest, as measured from the surface of the water or of the Plav, are in general those which arise from the most basal, that is to say, the least compound, of the *existing* rhizomes (Pls. **15** & **16**). The higher branches of the rhizomes are often closer together than the lower branches; hence the water circulates more freely below (see p. 259 & Pls. **12** & **13**).

Besides the scale and the bud, roots arise at the node. These are of two kinds: (1) mud-roots (see Pls. **11** & **12**), and (2) water-roots (see Pls. **11–17**). The mud-roots are situated on the portions of the rhizome buried in the mud, whereas the water-roots are situated higher up, where the rhizomes emerge from the mud-layer which, as a rule, covers the bottom of the lakes, and enter the water; and also on the stem portion in the water. Water-roots are more or less abundant practically at all the nodes in the water. Between the mud- and the water-root portion of the rhizome, is an intermediate portion where there are roots which are to some extent transitional between the two kinds (Pl. **11**). The mud-roots are soft and white and unbranched, have a conspicuous fawn-coloured tip, and sometimes attain a length of 3·5 m. (about 11 feet 6 inches) and a thickness of 6 mm.

(close on ¼ inch). The water-roots, on the other hand, are branched to the third degree, almost thread-like, hardish, brown, and up to about 15 cm. (about 6 inches) in length, and soil soon begins to accumulate on them (see Pl. **11**).

As the rhizomes become more and more compound, they play, together with the water-roots, an important part in uniting the growing reeds into a compact whole, their closeness increasing in proportion to their compoundness. Thus (1) the spaces between the rhizomes become gradually smaller, (2) contiguous rhizome-branches become intertangled and bound together by the numerous compound water-roots, and (3) the fine soil brought by the floods, and the organic matter contributed by the dead remains of the reed and other plants and also animals, are retained by the reed-roots, and thus in time the spaces between the rhizomes are completely filled up (see Pls. **12–17**). In this way the reed-tussock is gradually built up, and Plav, the aggregation of many reed-tussocks, arises.

The reed-tussock, with its open lattice of branches below and its long, simple mud-roots, is comparatively loosely attached at the bottom. Circulating water can do little towards washing away the soil retained by the close-growing upper portion of the reed *, more especially when the accompanying plants are established, but the mud overlying the sand-bottom where the more open-branched portion of the reed is, can, to some extent, be redistributed; hence the very structure of the reed *when it has reached, or nearly reached, full development* tends to instability, and therefore also liability to be uprooted by floods and storms at certain stages of its growth. (See pp. 258 & 259.)

Plates **11** to **17** show different stages in the development of the under-water portions of the reed-tussock.

Part II.

The Growth-Cycle of the Reed.

The Plant and Vegetation Units.

The present paper, though primarily concerned with the structure and mode of formation of Plav, is concerned ultimately with the senile degeneration and death of the reed: the conclusions arrived at as regards the latter question are, in fact, responsible for the manner of presentation of the subject-matter. Thus the term "association" is not used here, but two other units which define the individual—for with senescence and death, the question, What constitutes the individual? is inextricably interwoven.

The difficulty of defining the individual is obvious in the case of the reed;

* Even protracted use of a hose on a detached reed-tussock failed to free it of its soil.

accordingly its power of vegetative propagation is often commented on, in fact it is in itself held to be the cause of the difficulty—a clear indication of the general confusion which prevails as regards the individual in the vegetable kingdom as a whole.

To "dominant" plants of the growth-form of the grasses the term "association" ill applies, even though certain *stages of the growth* of the dominant—open and closed reed-swamp for example—are well defined as regards the "accompanying plants." The accompanying plants in the case of the reed vary according to its stage of growth, no matter whether it be in association, that is to say, consist of several individuals produced from seed, or merely of a single individual, or part of one, viz. one stool. The "vegetative reproduction" of the reed I conceive as equivalent in essence to the *growth* of the tree, that is to say, as somatic *development*, not vegetative *reproduction*. The term vegetative *reproduction* I regard as a misnomer engendered by, and responsible for, much confusion of thought.

Throughout this paper I postulate two plant units, or individuals: (1) a major—the soma—produced sexually, and (2) a minor, produced vegetatively, which builds the former up and is therefore contained within it. The major individual is, compared with the life of man, of long duration, and its limitation is therefore not obvious to us; moreover its soma may exist in several pieces, each piece consisting of one or several minor individuals. On the other hand, the minor individual is sufficiently short-lived to render the limitation of its life obvious.

I regard the major plant unit, viz. the total vegetative output which one fertilized cell is capable of initiating, as the most important unit in the vegetable kingdom, and possibly throughout biology, and its mass as the measure of specific vital energy. The minor unit which I postulate is either the forerunner of the bud, or the bud, or the shoot (the grown bud)—that is the somatic portion, which is able to produce a replica of the specific soma.

The minor plant unit is not a constant like the major—in the reed, at any rate, it decreases in size regularly with the age in generation of the shoot, and I believe that the plant (the major unit) finally ceases to produce it—hence the major unit dies. If sexual reproduction were therefore absent in any plant whatsoever, it would on the above conception cease to exist as a species.

I have not yet attempted to define the major unit of the reed experimentally, but I have made observations which I think justify me in postulating it, and which I hope will enable me ultimately to attempt its calculation, though doubtless the difficulties will be many and great. With the forlorn hope of finding some material for a preliminary calculation of the major individual of another plant, the output of which I might compare with that of the reed (see pp. 268–269), I searched through forestry data, but though a

considerable amount of material was available for the beech, it was far from sufficient.

Apparently no plant can be defined by mass as it stands, not even the annual, because an annual can be converted into a perennial through changes that affect its nutrition (see p. 249). The annual apparently belongs to a type of plant which owing to peculiarities of nutrition does not normally develop its mass even approximately. Trees such as the willow, which are readily multiplied by cuttings—and according to my conception this is not reproduction by artificial means—are also possibly unable to develop their mass in one whole even under the most favourable circumstances, but must be separated into parts to do so. The difficulties of the calculation of mass as regards the higher animals would seem to be even greater. Plants which are not multiplied by cuttings, the Coniferæ for example, would probably most readily lend themselves to investigation involving measurements of the major unit or soma. In any case, the investigation of the major unit is obviously of vast, it might almost be said of insuperable, difficulty : nothing less than the preparation of exhaustive monographs of a very different order from those so far undertaken will suffice.

The major individual, as already stated, I conceive to be a constant, and of prime importance. The circumstances under which a plant grows will not therefore, according to my hypothesis, essentially affect its final mass, provided of course that there is no actual crippling : whether the plant grow slowly or rapidly is in fact unimportant, for in either case the yield by mass of somatically produced material will be approximately the same. The vital energy of plants is in a static or in a kinetic state according to circumstances. Thus in some environments growth will be so slow as hardly to be perceptible, and the vital energy will therefore to a large extent remain stored, as follows from the fact that buds as well as seeds have the power of remaining latent for a time, and therefore many more years elapse in the development of the major unit than in an environment where growth is rapid, that is to say, where the vital energy of the plant is in the kinetic state (see pp. 269 & 270). In other words, the time factor is not fundamental as regards the development of the vegetal mass—the length of life of a plant major unit varies within very wide limits. The plant in fact has an age which can be reckoned in years, and also a biological age which I will call the absolute age, measured by the period, stage, or position which it has reached in its life-cycle (see footnote on p. 267).

The introduction of these questions in connection with the reed arose from the consideration of the significance of the great divergence in size of the reed-shoots forming different Plavs and different portions of the same Plav (see pp. 263–268), and from the conclusion that the large shoots were more youthful than the small ones, and that the plant finally ceases to produce even small shoots—that the major unit, in fact, dies owing to senescence.

Evidence that the death of the reed follows on senescence presumes proof, (1) that the different-sized shoots do not belong to different varieties of reed (see pp. 263 & 264), and (2) that death does not result from external agencies such as (*a*) unsuitable chemical or physical factors in the environment (see pp. 264–266), or (*b*) inter-competition with other plants (see pp. 266 & 267).

Consideration of these questions led me to theoretical conceptions out of which arose the attempt to define the reed individual and finally the question: what is the volume and mass of the major plant unit of which the single reed-shoots, the minor individuals, are the parts?

As regards the major unit I shall offer further on (see pp. 268 & 269) a suggestion with the full realization that it is nothing more. Nevertheless I believe that it rests on an actuality.

As is well known, the general biological questions here involved,—for example, the question of the adequacy of "vegetative reproduction" as regards the continuance of life in a species,—have been under discussion for a long time, in particular, recently, through the medium of the Protozoa * —I refer to the hotly debated question of the Life-Cycle—though plants have had their place in the discussions.

The late Professor Minchin †, referring to the Life-Cycle of the Protozoa, says:—"The cultivated banana-tree is propagated entirely by a non-sexual method—namely, by the production of suckers growing up from the roots, and in no other way. Whether this complete abolition of sexuality will in time lead to exhaustion of the cultivated race of banana remains to be seen, but at present there seems to be no sign of loss of vigour under cultivation."

The first important publication touching on senile decay in plants was the work of Thomas Andrew Knight; it appeared in 1795 ‡. Since his day there have been several publications of varying interest on the question, the most recent of which is that of Professor Benedict of Cincinnati §,

* A series of papers on the Life-Cycle of the Protozoa have appeared since the time of Ehrenberg, 1831 onwards to date. (See the papers on this subject by Calkins & Woodruff. In particular:—Woodruff, L. L., & Rhoda Erdmann, "A Normal Periodic Reorganization Process without Cell-fusion in *Paramœcium*," Jour. of Exp. Zool. Nov. 1914; and Calkins, G. N., "Cycles and Rhythms and the Problem of 'Immortality' in *Paramecium*," The American Naturalist, Feb. 1915.)

† Minchin, E. A., "An Introduction to the Study of the Protozoa." London, 1912. (See p. 136.)

‡ Knight, T. A., "Observations on the Grafting of Trees," Phil. Trans. Royal Soc. London, 1795: 2: 290–295, *fide* Benedict; and "On the parts of Trees primarily impaired by Age," Phil. Trans. Royal Soc. London, 1810: 178–183, *fide* Benedict.

§ Benedict, H. M., "Senility in Meristematic Tissue," Science, March 15, 1912; and "Senile changes in the Leaves of *Vitis vulpina*, L., and certain other Plants," Cornell University Agricultural Experiment Station of the College of Agriculture, Memoir no. 7, June 1915.

whose work marks the beginning of a new period in the study of plants, for, henceforth, the question of senility can no longer be ignored in the plant realm, but will have to be considered by workers in every branch of botany. Professor Benedict published a short, but important, paper on senile decay in plants in March 1912, seven months before I began my work on the reed, and another longer one in June 1915. The line of study he pursued differed widely from mine, for not only was his material different, but his work, unlike my own, was undertaken with a direct view to the solution of this question. The question as he framed it was: does the meristem of perennial plants retain its embryonic character unchanged? Professor Benedict answers this question by the statement that in perennial plants the leaf (according to my conception a portion of the minor individual) undergoes a definite progressive change in accordance with the age of the plant that has borne it, and he explains how this portion of the "minor unit" apparently indicates that there is a natural limit to the life of the "major unit,"—in fact, his studies lead him to believe that plants die owing to senility. He sums up (in his 1912 paper), with the advice to plant-breeders not to put their trust in cuttings in the case of plants that naturally reproduce from seed, but to develop fresh plants from seed.

The theoretical question: what constitutes the vegetable individual—which is so closely connected with the question of senescence and death—was frequently debated during the early part of the last century * and has recently again been under discussion, as also that of the animal individual. In the Contemporary Review for September 1913 † there was an interesting article on the plant individual, and the writer evidently believed that he had raised the question for the first time; the late M. Fabre, the entomologist, also discusses it in the introduction to Botany which he wrote for his son ‡; while on the Zoological side there is Professor Julian Huxley's "The Individual in the Animal Kingdom" §. Usually it is *either* the "minor" *or* the "major" individual which is discussed directly, in which case the other unit is usually implied, and appears, in fact, as a shadowy and incomplete part or whole, as the case may be.

* Du Petit-Thouars, A. A., "Essais sur la Végétation considérée dans le Développement des Bourgeons." Paris, 1809.

Gaudichaud, Charles, "Recherches générales sur l'Organographie, la Physiologie et l'Organogénie des Végétaux." Paris, 1841.

Braun, Alexander, translated by C. P. Stone, "The Vegetable Individual in its relation to Species," The American Journal of Science and Arts, 2nd ser. vols. xix. & xx. (1855) and xxi. (1856).

Gray, Asa, "Introduction to Structural and Systematic Botany and Vegetable Physiology," 5th revised edition of the Botanical Textbook. New York, 1860.

† Davidson, H. C., "The Nature of Plants," Contemporary Review, Sept. 1913.

‡ Fabre, J. H., "La Plante," 10th edition, Paris.

§ Huxley, J., "The Individual in the Animal Kingdom." Cambridge, 1913.

The question of senescnce is discussed on more general, *i. e.* biological, lines by Minot *, Dastre †, Child ‡, Metchnikoff §, and many others. Among the above publications I am particularly indebted to Professor Benedict's papers and also to the article in the Contemporary Review: these papers were of very great assistance in enabling me to define these problems.

The Growth Stages.

There are three more or less well-marked stages of growth of the reed, namely, the open and the closed reed-swamps, and, in deep waters, Plav. Each of these stages becomes automatically transformed into the stage immediately above it, hence the separating line between the stages is not sharp.

In shallow water, only two stages can be named, not because the development of the reed itself differs in shallow and in deep water, but because the closed reed-swamp of shallow water, though similar to Plav in structure, never becomes detached, that is to say typical, Plav. This "fixed Plav" of shallow water is sometimes joined to "floating Plav" and it passes into a reed-ledge as the water deepens. In all probability both the ledge and the fixed reed-platform into which it passes occasionally become buried under inorganic flood-borne sediment as Dr. Antipa has explained (see p. 246).

When all the stages are present, their order with reference to the open water is: (1) open reed-swamp, (2) closed reed-swamp, and (3) Plav. But not all water where there is reed is bordered by open reed-swamp; closed reed-swamp and Plav in some cases abut on the open water directly.

Open Reed-swamp.

The open reed-swamp is the stage at which the growth of the reed-shoots is as yet sparse.

Open reed-swamp advances more or less concentrically, if the spot on which it has settled has no irregularities. It advances from the edge of a lake and narrows down the central water-space, but it also occasionally forms small independent circular or oval patches away from the marginal reed-swamp. These reed-patches have apparently arisen from seed, or possibly, though improbably, from detached pieces of rhizome (see p. 250). I saw several such patches in Lake Merhei, in the northern portion of the delta. They were only a few feet in diameter, and probably not more than two or three years old, as the reed-shoots only rose some 0·6 m. (about 2 feet) above the surface of the water, and none of the shoots bore flower. In Lake Lumina I saw several much larger patches consisting of

* Minot, C. S., "The Problem of Age, Growth, and Death," New York, 1908; and "Problems of Modern Biology," Philadelphia, 1913.

† Dastre, A., "La Vie et la Mort." Paris, 1913.

‡ Child, C. M., "Senescence and Rejuvenescence." University of Chicago Press, 1915.

§ Metchnikoff, Élie, "The Nature of Man," 1903; and "The Prolongation of Life," 1908.

full-grown reed, and in Lake Roşuleţ, two fairly large sized reed-islands with a rim of open reed-swamp outside and a Plav kernel within *.

Open reed-swamp is of different widths. This difference of width of the open stage of growth would appear to follow as a matter of course in any plant that advances concentrically. The *radial* advance of reed spreading from a centre must inevitably diminish even though the vegetative output of the reed be on the increase, because the circumference of the successive circles increases—the fresh area covered each year may be greater and yet the radial advance less. If we suppose that the fresh *area* acquired annually be the same, the radial advance will decrease steadily, and may finally be so slight as hardly to be perceptible, in which case closed reed-swamp will in time abut on the open water and the reed-swamp appear to be stationary. Naturally physical obstacles such as too great depth of water † will stop the reed from advancing, in which case also closed reed-swamp will in time abut on the open water. Even minor inequalities of the bottom influence the direction and manner of growth of the reed. Thus the closed reed-swamp stage will appear in some spots sooner than in others. The annual increment of the reed is certainly on the increase as long as the reed is advancing horizontally, because not only does the reed acquire fresh territory each year, but fresh shoots also arise each year all over the area already occupied; in fact, the shoot output at first, at any rate, increases behind the vanguard. There appears to be no decrease in the annual increment until close on the time when the reed ceases to advance horizontally and becomes detached, *i. e.* Plav. The reed, about the time of its detachment, produces, per annum, per 4 square metres (6 feet 6¾ inches across or about 43 square feet), about 50 to 60 shoots which reach the air, their weight (green) being from 14 to 17 lbs. (about 6·8 to 7·7 kilogrammes) (see pp. 265 & 268–269).

If 50 shoots reach the air, then there must be 50 new pieces of rhizome, since the portion of shoot in the air is the continuation of the rhizome (see p. 248). These rhizomes do not, however, all arise from the base—some are relatively short (see p. 267). Two basal rhizomes taken from a swamp weighed (green) about ¾ lb. (about 340 grammes), each. Therefore, allowing 10 basal rhizomes per 4 square metres (43 sq. ft.) at ½ lb. (about 225 grammes) each, and 40 at ¼ lb. (about 113 grammes), the output of rhizome per annum per 4 square metres is at least 15 lbs. (about 6·8 kilog.).

Now the extremities of shoots of three years' standing often occur at the surface (see p. 248), and as their rhizome portion is perennial, even though they themselves are annual, the total weight of rhizome per 4 square metres (43 square feet) is at least 45 lbs. (about 20·4 kilogs.), the

* I sounded the larger of these islands and found a shoal.

† I have found reed growing in water up to 2·8 m. (about 9 feet 6 inches) deep at high water in the Danube.

living aerial portions of the shoots weigh roughly 15 lbs. (6·8 kilogs.) (see p. 265), and probably much more; from which it also follows that the reed-rhizome is renewed completely *at least* once in three years.

Closed Reed-swamp.

Closed reed-swamp develops from open reed-swamp automatically, as explained, and in time becomes Plav. It is of many degrees of maturity, and therefore is composed of reed-tussocks of many sizes.

Thus in one spot all the reed-stools are rooted, and their tops are therefore well under water, and in another spot they are, owing to the growth of accompanying plants, almost level with the surface of the water. In this way in some places where land-plants are already settled on the stools the reed-swamp has the appearance of a secure land-surface, though a slight pressure suffices to push the stools under water *.

Much soil is held both by individual tussocks and by closely growing assemblages of tussocks. Three layers of soil (fluvio-lacustrine ooze) are distinguishable, just as in Plav. The colour of the soil is greenish-grey and lighter than that of Plav, and the top layer of black soil contributed by the land-plants rooted in some of the tussocks is less thick than in Plav, and sometimes absent, as is to be expected since the land-plants are new-comers. At the closed reed-swamp stage fluvio-lacustrine ooze usually covers the sand bottom on which the reed originally established itself.

In old closed reed-swamp a considerable number of the basal connecting rhizomes are dead, hence the stools are often attached to each other more securely above than below. The lattice of branches, also, as already explained (see p. 250), is more open below and there are no water-roots; thus the basal portions of the reed do not hold soil, and circulation of the water proceeds more readily below than above. The reed, in fact, tends to become less secure as regards attachment to the bottom the older it gets, and detachment apparently follows quite naturally at a more or less *fixed time*: first, because of the death of the basal rhizomes, and secondly, because the tussock increases in size, and above also in solidity; hence the water circulates readily below but exerts pressure against the solid upper portion of the stool. In other words the greater the base of the stools the greater the

* This stage of swamp is quite well marked and has received the name of *Bouharnik* from the fishermen—the significance of which I have not been able to learn. It apparently has some jocular meaning connected with the ease with which it is possible to founder in trying to step from stool to stool.

The Russian fishermen distinguish other stages of reed-swamp also—for instance, *Ritkovina Riceavina, Ritkovo*—open reed-swamp through which a *lodka* (boat) can be forced; *Triceaba,* closed reed-swamp through which a lodka cannot pass; *Opoushena,* reed-swamp formed of large tussocks through which a lodka can thread its way.

pressure, and therefore the greater the pull on the rooted portion; thus aggregations of tussocks solidified above by earth and by accompanying plants are more likely to become detached than smaller tussocks. I do not think that water-pressure caused by floods is absolutely necessary in order that detachment of the reed should take place. It may in water as deep as that of the delta become detached merely owing to the death of its basal rhizomes, though detachment must naturally take place most readily under conditions which tend towards instability, that is, during floods and storms *.

Were floods the master-factor as regards the detachment of the reed, there would hardly be any rooted reed in the delta, since floods occur generally twice in the year, whereas in general *reed of a more or less definite stage of development becomes detached*, and yet reed-swamp is far in excess of Plav. In fact, I do not regard a soft bottom and floods as the essentials of Plav formation (see p. 244).

That the detachment of the reed is not, however, merely due to its structure and age, but also to some extent to its environment, is shown by the facts (1) that there is practically no Plav beyond the delta, (2) that Plav does not arise everywhere in the delta, but only in deep water, and (3) that in the Norfolk Broads no Plav is formed, though the reed forming the fen has a distinct basal decomposition-layer.

The absence of Plav beyond the delta is, I think, attributable to the *magnitude* of the floods, which carry a very much greater amount of fine inorganic silt, a large amount of which is finally deposited in the quiet reaches of the Balta. The reed, however insecure it may become through the processes of its growth, is constantly being planted afresh through the deposition of this silt. Thus around Tulcea, in the Somova plexus of lakes, very little Plav (the Prundoae of the local fishermen) is formed (see p. 245), and higher up the river where the deposition of silt is still greater, near Brăila for example, I have not seen even Prundoae. The reed there grows *on a ledge of silt* because the quantity of silt is so great that practically wherever there are plants, a bank is formed extremely rapidly. Many of the reed-thickets around Brăila can be crossed on foot dryshod.

That Plav does not arise in shallow water around the grinds is due apparently to the smallness of the space under water: the reed therefore fills it completely. Hence it is far better secured than in deep water, and forms a most compact platform similar to Plav in structure although, unlike it, it is attached to the bottom. The water is often only a few centimetres deep above these platforms though they look like the ordinary swamp, or, rather, are liable to be taken for such by anyone unacquainted with the configuration of the ground. In time the space between the surface of these

* The *Typha angustifolia* around the edge of Horsey Mere floats because its basal parts have died. The rise and fall of the water in Horsey Mere is more or less irregular.

platforms and high-water-level becomes filled owing to the activity of aquatic and land plants (see Pl. **24**, section III.), and a land-surface is formed.

No Plav is formed in the Norfolk Broads because the common Norfolk variety of reed, which invades water not more than about 1·2 m. (about 4 feet) in depth, manages to fill the water-space completely before basal decomposition is at all general; that is to say, decay does not generally set in in the swamp-stage, but in the fen-stage. A reed-fen which I sectioned with the rizak close to Sutton Broad Laboratory, had a regular decomposition-layer at the base (see Pl. **24**, section IV.). Four vertical cuts were made in this fen * with the rizak, and the resulting block was then lifted out with very little effort. The little resistance offered was due to the presence of a few long mud-roots which proceeded from the upper living reed into the soft fen soil below. Were a decomposition-layer present in *swamp-reed*, it would seem that it must float, in fact become Plav, just as some of the *Typha* around Horsey Mere does.

Plav.

Plav, when newly detached, does not differ from closed reed-swamp except in that it floats. In time, however, its resemblance to closed reed-swamp becomes less: the sub-aquatic layer of rhizomes, rootlets, and soil becomes more consolidated ; the soil darker ; the top layer of soil contributed by the accompanying plants thicker ; and the reed-shoots, the minor individuals, decrease in size. Plav, in fact, is a dense floating thicket of reed, the shoots of which rise 1·2 m. to 5·15 m. (about 4 to about 17 feet) above its surface, with a more or less dense undergrowth of accompanying herbaceous plants (see Pls. **18–21**).

That Plav floats is not obvious to the eye, but to the fisherman of the delta it is a matter of common knowledge. It is necessary to section it, or, better still, to observe it in relation to the rise and fall of the water in order to realize this fact.

It is possible to demonstrate that it floats in various ways. For instance, if two parallel cuts be carried inwards from the edge of a Plav, and a series of cross cuts be made between, a number of free floating blocks are liberated. This demonstration applies, however, in particular to the edge of the Plav, not necessarily to the whole. That it floats as a whole becomes obvious during the floods, for it never becomes flooded—it retains the same relative position to the water-level.

The movement of the Plav is vertical only, as Plav, if not attached, is prevented from moving horizontally. These remarks naturally apply only if "Schwimmende Inseln," which move horizontally (see below, and p. 243),

* The contemporary fen-layer, that is to say, the root-layer formed of the parts of living plants, is in some places 3 to 4 feet in thickness.

are regarded as *pieces* of Plav, not as complete Plavs, the former of which is contrary to my opinion.

Some Plavs are certainly attached—for instance, those forming the continuation of the rooted reed-platform of the shallow water round the grinds (see p. 243)—but Plav also occurs in places where connection with a grind is impossible. In such cases it may be that the Plav is attached, at one side, to a shoal under water, or to the rooted-reed of the adjacent reed-swamp; or it may be that the Plav, though originally completely unattached, has come to rest on one side owing to subsequent local heaping up of fluvio-lacustrine ooze; or possibly, in some cases, the Plav is not attached at all but is prevented from moving horizontally because it happens to be almost, or completely, surrounded by reed-swamp. If a completely detached Plav happened to become liberated where no swamp barrier existed, it would drift about freely, and, in fact, be one of Dr. Antipa's "Schwimmende Inseln."

Floating-islets are, however, as a rule very much smaller in area than Plavs, which possibly indicates some fundamental difference. However in Lake Iacob, near Caraorman, I sectioned a floating-islet which was quite as large in area as an ordinary Plav. In any case, the round or oval shape of these islets (see Pl. **21**) appears to me to preclude the possibility of their being small *pieces* of Plav *sliced off* by ice. If, then, floating-islets are not *pieces* of Plav, Plav and floating-islets are one and the same thing, and, in that case, Plav must be described as occurring both fixed and free-floating, according to circumstances, and therefore as moving both vertically and horizontally.

The thickness of the aquatic portion of Plav varies. The average thickness of twenty of the sections I made was 1·34 m. (about 4 feet 4 inches). The thickness of Plav, however, ranges from about 2 m. (about 6 feet 6¾ inches), in the case of Maximou Kut, a Plav on the north-east side of Lake Roşuleţ, to 0·8 m. (about 2 feet 6 inches), or even less. The same Plav also varies in thickness in different places. Thus the Plav on the west side of Sherneshenko Sahi *, a small sheet of water off the north-east side of Lake Roşuleţ, is only 0·8 m. (about 2 feet 6 inches) at the edge, whereas a few yards further in, it was about 1·45 m. (about 4 feet 9 inches).

This variation in thickness is probably due to the fact that a *Plav grows a little at the edge,* and thus slightly extends its area. The rhizomes at the edge of the Plav loop round and up to the surface (see Pl. **14**). That there is slight growth there, is also borne out by the fact that the arrangement of the rhizomes at the edge of a Plav is highly irregular: the rhizomes,

* The Russian fishermen call the smallest sheets of water Sashka, larger lakes Saha or Sahi, and the largest Liman, *i. e.* lakes like Roşuleţ, Roşu, etc. In the Norfolk Broads the smallest sheets of water are called Pulk-holes.

instead of running straight up vertically, as they do further in (see Pls. **15** & **16**), straggle round and up at many different angles* (see Pl. **17**).

When the reed becomes detached it is perhaps slightly less in thickness than the full-grown stools of closed reed-swamp. The largest stool I measured was over 2 m. (about 6 feet 6¾ inches), and the average of seven full-grown ones 1·8 m. (6 feet), as was indeed to be expected, since Plav arises from closed reed-swamp to a great extent owing to the death of its basal rhizomes. The hanging dead parts must soon fall away when the reed is floating, since dead rhizomes are not a conspicuous feature of the base of a Plav but occur more or less equally throughout it. I have never seen a layer of dead blackened rhizomes such as Dr. Antipa mentions.

Whether an old Plav is less thick than a new one, I cannot say. As a Plav ages it wastes below; that is to say, the reed layer decreases, but there is a gain of soil above, the contribution of the accompanying plants. Thus it may well be that the thickness of a Plav, as a whole, remains more or less unchanged so long as it remains floating, but that its composition changes.

Plav has at least three distinct layers of soil. Normally, there is (1) the top layer of black earthy-looking soil usually from about 6 cm. to about 15 cm. (about 2·5 to 6 inches) in thickness, contributed by the land-plants; (2) a layer of fine soil of a dark brown colour whose organic content is about 40·7 per cent.; and (3) a basal layer of coarse brown soil with an organic content of about 17·6 per cent.† The fineness of the soil of layer (2) is probably due in part to the breaking up of the soil by the roots of the accompanying plants, and also to the fact that the coarser inorganic matter carried by the floods has to filter through layer (3) first. I have found an earthworm in Plav on one occasion only—in Maximou Kut Plav. I did not estimate the organic content of layer (1), but its soil is almost black, and must therefore contain a higher proportion of organic matter than layer (2). The floods do not come into direct contact with this layer, hence its inorganic matter is probably only plant-ash (see Pl. **15** & Pl. **24**, sections I. & II.). Many long water-roots, clean because suspended in the water, hang from the base of the Plav (see Pl. **15** & Pl. **24**, sections I. & II.). Inside the Plav layer there are many mud-roots;

* At Salhouse Broad, in Norfolk, I found a sill of reed about 1·4 m. (about 4 feet 7 inches) wide and about 0·5 m. (about 20 inches) in thickness, which had evidently grown over the water which is there about 1·5 m. (about 5 feet) in depth. The structure of this sill was similar to that of Plav, being formed mostly of vertically running rhizomes. A reed-layer formed mostly of horizontal rhizomes, such as described (p. 244) and figured by Dr. Antipa, does not appear to exist.

† The organic matter of layers (2) and (3) was estimated for me by Mr. F. J. Farrow, to whom my thanks are due. Only one soil sample was examined in each case; the figures are, however, likely to be fairly representative, as the samples were typical in appearance. These three layers are quite easily distinguished in the field.

that is to say, thick unbranched, or almost unbranched, roots, often of great length. Many of these roots are constricted at frequent intervals.

The Minor Individual.

The reed-shoots forming Plav, as already stated, are of several sizes. A Plav may be formed of one thicket of reed, the shoots of which are more or less of one size, or of several thickets, each formed of a distinctive size of reed and sharply separated from the others. There is, naturally, some variation of size within a thicket, but the dominant difference in size of the reed of different thickets, even though contiguous, is so marked in the delta of the Danube that it suggests the presence of several varieties of reed (see Pls. **18–21**).

The reed groups itself quite naturally into two main divisions as regards size. In the one group are all the reeds which I call "giant," or, better, "stout," since there are short ones amongst them: these I regard as the juvenile form. They reach a height of about 5·15 m. (about 17 feet), as measured from the surface of the Plav. The other group includes the aged form of the reed, the slenderer and shorter reed, the *Shitka Kamish* of the fishermen, which varies in height from 1·2 m. or less to about 3·3 m. (about 4 feet to about 11 feet). A reed-shoot, whether tall or short, can generally be assigned to either group, stout or slender, at a glance. Each of these two main groups can be further subdivided into tall-stout, tall-slender, short-slender, etc. In this case too the reed of each thicket is more or less uniform in size *. The height-classes of the slender reed are more numerous and conspicuous than those of the giant reed.

That difference in size of the reed of the delta of the Danube does not signify difference of variety is shown, apart from the identity of the flowering parts:—

(1) By the fact that the reed forming open and closed reed-swamp is almost invariably † stout, whereas slender reed is a Plav plant. Were slender reed therefore a distinct Plav variety, the obvious position in the Plav for its rhizomes would be above those of the stout reed and never at the base of the Plav, since Plav is formed of detached swamp reed, which is stout reed. Slender reed, however, when present in a Plav, occurs at its base—it occupies the position of a swamp plant without having been one.

* In a smaller way, these divisions are also to be seen in Norfolk, around Sutton and Barton Broads for instance.

† I found one exception to this rule at Ghola Kossa, a low grind on the south-west side of Lake Roșu. A narrow row of slender reed, whose total length was about 3·15 m. (about 10 feet), was growing there in water about 1·65 m. (about 5 feet) deep on September 6th, 1913. I can offer no explanation for this exception.

Many fragments of marine shells occur at Ghola Kossa, viz.:—*Cardium edule*, Linn., *Mytilus edulis*, Linn., mixed with fresh-water shells such as *Planorbis corneus*, Linn.

(2) By the fact that each size of reed forms an entire Plav, or an entire portion of a Plav. Were the different-sized reeds different varieties, they would certainly sometimes mingle, just as happens in the case of accompanying plants which, as a rule, form separate societies. Further, the submerged layer of a Plav formed of thickets of different-sized reed can be separated into pieces of Plav formed entirely of one size of reed by vertical planes only: the different sizes of reed are never superimposed upon one another. Were the different sizes different varieties, they would certainly sometimes form mixed strata, or horizontal strata superimposed upon each other, just as the swamp-plants *Typha angustifolia*, Linn., and *T. angustata*, Bory & Chaub., form horizontal strata above *Phragmites communis*, Trin., and *Phragmites communis*, Trin., *β. flavescens*, Gren. & Godr., respectively, and thus sometimes together build up one fen in the Norfolk Broads, or one Plav in the delta of the Danube (see Pl. **24**, section II.).

Since reed of any size may in the delta of the Danube form an entire Plav, or portion of a Plav, from the base upwards, all these size-classes of reed, including slender reed, must originally have been swamp plants, although only one of them, namely stout reed, is to be seen in the swamps. The explanation of these apparently contradictory facts is, I believe, that a gradual change takes place in the reed whereby slender shoots are produced in place of the original stout ones, and that this change in the shoots takes place only after the stout reed, the reed of the swamps, has become detached and reached the Plav stage. Thus stout and slender reed do not represent different varieties. They are in fact the lower and higher branches of one vast branch-system, which do not co-exist but succeed each other. Stout and slender reed is thus made up of shoots, or minor individuals, of different age in generation. The production of increasingly slender shoots, or minor individuals, by the plant, the major individual, therefore indicates a gradual progressive morphological change in its constitution—a change which culminates in death, since the shoot-output begins to decline after the reed has reached the stage at which it produces the shortest slender shoots (see pp. 267 & 268).

To what cause is the change in the reed-shoot attributable? It may be either external to the reed, for example (1) poisoning by its decayed dead remains, (2) overcrowding of the rhizomes or the aerial portions of the reed, (3) change in the physical environment, that is to say, a change in the relation of the surface of the Plav to that of the water, and (4) inter-competition with the accompanying plants; or the cause may be inherent to the reed. It is to the last cause that the change in the reed is, I think, to be attributed, viz., to senile degeneration, the inherent progressive change that culminates in death.

I believe this to be the explanation, *first*, because (*a*) slender reed is apparently quite as healthy as stout reed. There is no change in the

No.	*Locality.*	*Kind of reed.*	*Length of stem.*	*Number of reed-stems per unit-area. (4 square metres.)*	*Weight of reed-stems per unit-area.*	*Kind of undergrowth.*	*Weight of undergrowth per unit-area.*
I.	Nazaraou Rinok, Lake Roșuleț.	Stout (tall).	About 5·15 * m. (about 17 feet).	51	$15\frac{3}{4}$ lbs. (about 7·1 kilog.).	*Polystichum Thelypteris* (630 fronds per unit-area).	9 lbs. (about 4 kilog.).
II.	" "	"	" "	54	" "	Do. (825 fronds).	$7\frac{1}{2}$ lbs. (about 3·3 kilog.).
III.	Balanova Saha, near Lake Roșu.	Slender (tall).	About 3 m. (about 9 ft. 9 in.).	373	$16\frac{3}{4}$ lbs. (about 7·6 kilog.).	Mixed undergrowth. See footnote on p. 271 and Appendix D pp. 278–9.	Not weighed.
IV.	Near Balanțicova Sahi, between Lake Roșuleț and the sea.	Slender (tall-medium).	About 2·6 m. (about 8 ft. 6 in.).	473†	$14\frac{1}{2}$ lbs. (about 6·5 kilog.).	" "	$5\frac{1}{4}$ lbs. (about 2·6 kilog.).
V.	Grind of Roșuleț.	Slender (medium).	About 2·2 m. (about 7 ft. 3 in.).	550‡	$16\frac{1}{2}$ lbs. (about 7·4 kilog.).	—	—

* Reed-stems of the 4 m. (over 13 feet) lengths are all stout. Slender reed begins in the 3 m. (about 10 feet) lengths.

† This reed was burnt last year.

‡ In this case I counted and weighed the old dry standing shoots as well. They numbered 543 and weighed 8 lbs. (3·6 kilog.).

healthiness of appearance of the reed from the open reed-swamp stage to the time when, as Plav, it gradually declines in size. Some tests which I applied seem also to confirm this. I had all the reed from a unit area, 4 square metres (6 feet 6¾ inches across), cut and weighed, green, on the spring-balance (see p. 235). The results were :—

These few tests indicate that the output of reed in weight per unit-area varies relatively little whether the reed be tall-stout, tall-slender, medium-slender, etc. Apparently, therefore, according to these tests, the major individual is more or less equally vigorous at each of these periods, which would not be the case were it poisoned.

(*b*) Because, when the reed becomes detached, there is already an accumulation of fluvio-lacustrine ooze covering the bottom of the lake—ooze that contains a considerable amount of organic matter proceeding from the reed itself—yet there is no change in the size or healthy appearance of the reed that has become detached; so strictly localized an effect appears improbable on the assumption of the presence of poison.

(*c*) Because though, in general, the periphery of a Plav or reed-swamp is liable to better conditions of aeration than its centre, yet the reed-swamp abutting on open-water often becomes detached first (many Plavs abut on open-water), and also the reed of the interior of a Plav may become slender later than the reed at the edge of a Plav *. Were poisoning the cause of death of the basal rhizomes, and therefore of detachment, or of the change in size, one would expect the stage, whether of detachment or of decrease in the size of the shoots, to take place, as a rule, in the interior of a swamp or of a Plav.

Secondly, as regards the factor overcrowding. This does not seem to operate unfavourably, as one of the most crowded reed-beds—that around the grind of Roşuleţ (see No. V. of the table on p. 265)—is full of vigour, and produces 16½ lbs. (about 7·4 kilog.) of aerial shoots per unit-area. Nor do I think that crowding in itself—that is, without injury to health—has the effect of causing the production of small shoots. Among the short variants are some exceptionally short ones, yet the reed as a whole never becomes reduced to their length; it dies before, though buds still exist from which, one would suppose, yet smaller shoots could be produced. Apparently when a definite stage in the compoundness of the reed-system is reached, the reed major unit dies owing to vital exhaustion.

Thirdly, as regards change in the relation of the surface of the Plav to that of the water-level. There is practically no such change so long as the Plav remains floating. In this respect, Plav, "fixed Plav," and fen differ.

Fourthly, that death is not caused by inter-competition of the reed with the accompanying plants, is quite evident. The accompanying plants,

* Of course, wind or waves affect the edge of a swamp more than the interior; hence, possibly, slightly less ripe reed may become detached there.

apparently, are wholly dependent on the shelter from the climate afforded them by the reed. Thus, when the reed dies and the shelter is reduced, although the accompanying vegetation remains in possession of the Plav, its constitution changes (see pp. 270–271). There is no steady increase in number of the accompanying plants as the reed ages, only a change of species; in fact, the accompanying plants appear to decrease in number, judging by the weight (see No. IV. of the Table on p. 265), though, since the species differ to some extent, the weights are not strictly comparable. Further, there is no root competition with the reed, since the accompanying plants are all superficially rooted. The reed is obviously a true dominant, the accompanying plants being dependent on its presence, whilst it is wholly dissociated from theirs.

The sum of the facts given with regard to the minor individual, the reed-shoot, leads, it seems to me, inevitably to the conclusion that the decrease in size of the reed-shoots is inherent to the constitution of the reed major individual—in fact that it is a progressive morphological change which registers the passage of time as regards the reed major unit; or, in other words, that it is a measure of its *absolute age*—an indication of the point reached by the reed in the running of its predestined course the end of which is death. On this explanation the giant shoots are those which have arisen earliest and at the base of the branch-system *, and the slender ones such as have sprung from it later and higher up, whilst the shortest slender shoots are highest up in the system. As already explained, however, short shoots do not necessarily in themselves indicate loss of vitality (see Table on p. 265) in the major unit, but they herald it †.

The decline in size of the reed-shoots apparently follows merely as a result of the increase in compoundness of the reed-system in the vertical direction. The tallest shoots of a Plav nearly always arise from the base; they are the lower branches of the reed-system, and therefore less compound with reference to the *original basal rhizome* than their fellows; and this constitutes

* I would suggest, tentatively, that the sequence of shoots in plants is preordered or morphological, and therefore more or less definite—that is to say, is essentially independent of nutrition. The beech, for example, produces full crops of good seed in England, generally from 50 or 60 years of age onwards. I would suggest that this is not owing to the accumulation of nutritive substances, but because the beech takes 50 to 60 years, under a normal output of branches, to reach the stage in its life-cycle at which branches bearing numerous flowers appear: the plant must produce a more or less fixed *quantity* of branches of one kind before it can produce the more fertile branches of the next stage, see p. 253.

† As regards the possibility of internal factors such as decrease in the efficiency of the absorbing and conducting organs, or the presence of internal toxins (see Benedict's 1915 paper, pp. 325–330) causing the change in size of the shoots, I can only repeat what I said on pages 264–266, viz., that the vigour of appearance and of output of the reed is unimpaired for a considerable period after it has entered on the slender-shoot stage, which would be unlikely were it suffering from lack of food, or were it becoming poisoned.

the most obvious cause of fluctuating variation in length of the aerial shoots of one single reed-thicket. The reed-rhizome is often compound to the sixth degree, and, in general, the highest compound is the shortest branch, not merely as a whole, but even as regards its aerial portion (see p. 250). A great deal of the variation in size of the aerial shoots of one reed-thicket—for example, within a thicket of giant-reed, tall-slender reed, etc.—is therefore more apparent than real; and could *real fluctuating variation* be eliminated, the difference in length of the tallest and shortest aerial portions of the reed-shoots of one thicket would express the degrees of branching—which I have never found to be more than to the sixth degree—existing together at any one of the different periods of growth of the major individual. The size of each fresh generation of shoot is, in fact, closely co-related with the size of the generation of shoots preceding it, just as the sizes of the shoots of one generation are co-related as indicated above. The size of the shoot is a more or less exact measure of the absolute age or period of growth of the reed major unit.

The variation in the size of the shoots in any one thicket is much smaller than that obtaining between tall-stout and short-slender reed. The magnitude of the latter variation expresses, I believe, the total compoundness of branching which the reed major unit attains; it is the expression of the very high degree of branching of the reed with reference to its *original dead and vanished basal rhizome.* The branching of the reed is indeed comparable to that of the tree, but its trunk and its lower branches do not, as in the tree, persist throughout its life. Nevertheless its first shoot and its last are morphologically co-related.

The Major Individual.

The recognition of stout and slender reed as younger and older reed respectively, makes it possible at a glance to distinguish the old Plavs, and the older portions of a Plav; thus the areas covered by reed of different ages can be measured, and, further, it becomes evident that Plav often arises in comparatively small pieces. I took a few very rough measurements with a tape-measure, and also by pacing, and I do not think that it is usual for Plav formed of stout reed—*i.e.* newly-risen Plav—to be more than 50 squared metres (about 55 yards across) in area. If the thickets of different-sized reed which together form the larger Plavs became detached on separate occasions, the large Plavs must be regarded as compound structures.

The question arises: are the above data of use in establishing the major unit? Is the major unit a whole Plav consisting perhaps of several thickets formed of different-sized reed, or is it a single thicket? This question cannot be answered now. If a Plav consisting of several thickets be assumed to be the major unit, the sharply-marked difference in size of the reed of contiguous thickets demands explanation, since a gradation in size coincident with the

gradation in age would *à priori* appear probable. On the other hand, if the single thicket be assumed to be the major unit, it is necessary to explain how the different thickets have become joined together—how did they come to be so closely welded? Though I can make no assertion, it seems to me possible that the accompanying plants could effect such a union.

If the *single thicket* be assumed to be the major unit, its area as 50 squared metres (= 2500 square metres) and the annual output of leafy shoots as 15 lbs. (6·80 kilog.) per 4 square metres (43 square feet), then the total annual output of aerial parts is 9375 lbs. (4252 kilog.), and if the annual output of rhizome also be taken as 15 lbs. (see p. 257), the total output of reed per year is 18,750 lbs. (8504 kilog.). Then, with a length of life of 100 years (probably as a rule a low figure *), the mass of the reed-thicket (green) is about 837 tons (850,400 kilog.). If, on the other hand, a whole Plav be assumed to be the major individual, the figures would be about three times as great, *i.e.*, 2511 tons (2,551,200 kilog.). These figures naturally represent the minimum mass, since there is no proof that the reed is not able to form a very much larger mass if divided. The figures must rather be taken as comparable to the mass of a tree which cannot be multiplied somatically.

So far I have no figures regarding the length of life of a reed-thicket, nor have I a reliable notion of the initial annual horizontal increment of the reed, both of which would be of some help in arriving at an approximation of its mass, though, as explained in the introduction to Part II., I regard both these figures as variables within wide limits (see p. 253).

The Reed and its Competitor Typha.

One plant, *Typha*, competes successfully with the reed (in the delta of the Danube it is *Typha angustata*, Bory & Chaub., and in the Norfolk Broads *T. angustifolia*, Linn.), though I do not think that it ever supplants the reed absolutely, but merely inhibits its growth for a time.

In the delta, *Phragmites* invades deeper water than *Typha*, hence it is only in shallow water, or in water whose depth has been reduced by the reed-rhizome, that *Typha* and *Phragmites* enter into competition. Thus *Typha* often settles on the reed-rhizomes, and then, together with the reed, builds up one Plav, in which case, if judged by the aerial parts, *Typha* appears to be the dominant plant, for the reed sends very few shoots to the surface. If, however, the Plav is sectioned, it will be found to consist of living reed-

* On the assumption that equal areas are covered by the reed each year, its radial advance will decrease (see p. 257). With a circle of 25 yards (22·86 metres) radius, therefore, and allowing 100 years for that radial advance, the radius of the initial circle is 7½ feet (2·28 metres)—too great a figure judging from the size of the reed-patches I saw on Lake Merhei (see p. 256); hence the length of life of the major unit of the reed would appear to be greater than 100 years.

rhizomes below and of *Typha*-rhizomes above (see Pl. **24**, section II.). I believe, however, that *Typha* finally disappears and that the reed then resumes its interrupted course of growth: in the above case the reed probably remains "giant" for a longer period of *years*, because—its normal output of branches having been inhibited—it is still in an early stage of branching when it resumes its full normal growth, *i. e.*, it is morphologically still juvenile (see footnote on p. 267 and also p. 253).

The *Typha*-rhizome apparently has a short life compared with that of the reed; the rhizome-layer of *living Typha angustifolia*, for instance, is rarely 20 cm. (8 inches) thick, though the whole *Typha*-layer may be more than double that thickness. All the lower portion consists of dead rhizomes and rootlets in different stages of decomposition and yields a reddish evil-smelling ooze. There is, in general, *much more* and presumably much earlier decomposition in a *Typha*- than in a reed-layer, hence also the ease with which a reed-swamp can be crossed on foot, as compared with a *Typha*-swamp.

That the reed is merely inhibited for a time appears to be highly probable from the fact that in Norfolk, for example, there is no *Typha*-fen, though *Typha* occurs as a rare accompanying plant of fen, and yet is, as already explained, often the successful competitor *in the beginning* *. The youngest fens are nearly all *Phragmites*-fens, even where there is a *Typha*-swamp in the water immediately in front of them.

The Succession on Plav and East Anglian Fen.

The reed is, I think, succeeded either by another dominant, *Cladium Mariscus*, R. Br., or, if no plant present is able to take its place as a dominant, by a mixed assemblage of the plants which accompany it, giving rise to mixed-sedge-fen.

In East Anglia, the succession following on the death of *Phragmites* greatly resembles the one on Plav. East Anglian reed-fen is followed by sedge-fen often with *Cladium* dominant, or by mixed-sedge-fen consisting chiefly of Carices amongst which *Carex stricta*, Good., and *Carex riparia*, Curtis, are usually the most abundant species (see Appendix D, p. 277). After the mixed-sedge-fen stage, the succession in Rumania and East Anglia differs markedly. In East Anglia, carr-, *Juncus obtusiflorus*-fen, or *Molinia cærulea*-fen follow, and in Rumania salt-marsh plants appear as a direct result of the climate (see Appendix D, p. 279).

Good examples of typical sedge-fen, with *Cladium* dominant, occur in many spots on Sutton-High-Fen, on the river Ant, and in Breydon-Horsey (see Pl. **22**. fig. 2), both in the Norfolk Broads, and also in the well-known Wicken sedge-fen of Cambridgeshire. On Sutton-High-Fen, mixed-sedge-fen, *Juncus obtusiflorus*-, and *Molinia*-fen are also to be seen; the latter stages also occur in Wicken fen.

* *Typha angustifolia*, Linn., and *Phragmites communis*, Trin., both invade about the same depth of water in the Broads, *i. e.*, a maximum of 4 feet (about 1·22 m.).

In Rumania, in the steppe region, which bounds the delta of the Danube, the rainfall is low and evaporation high, hence there is a tendency for salt to appear : consequently, the edge of many of the grinds in the delta is a zone of salt-marsh ; in fact, on the island of Letei, the largest grind in the northern portion of the delta, the village commons are in some cases a splendid crimson in the autumn, owing to the abundance of *Salicornia herbacea*, Linn., and *Suæda maritima*, Dumort. The vertical zoning practically everywhere in the delta and in the steppe, is—fresh water in deep depressions, followed at a higher level, *i. e.* at the evaporation level, by salt water, and above that by a zone with practically no water. Briefly the vegetation succession is Hydrophyte, Halophyte, Xerophyte.

On Plav, the succession is apparently more or less the same as in the delta in general. After the tall dominants have disappeared, the steppe climate comes into direct contact with the low-growing herbaceous plants, with the result that salt-marsh plants begin to appear amongst the fresh-water marsh plants: it seems therefore *probable* that *climatic* salt-marsh will finally succeed the reed and *Cladium* on Plav *. In Appendix D, p. 279, a list is given of the salt-marsh plants gathered on Ivan-Mekitenko-Plav, probably the oldest Plav I examined, from a spot where *Phragmites* was absent, and *Cladium*, which was present on one side of the Plav, had not yet spread. The salt-marsh plants are, however, not yet abundant.

For lists of the plants of the delta of the Danube and of the Norfolk Broads, see Appendix D. The succession of the species and of the vegetation in the delta of the Danube and in East Anglia is summarized on pages 272–273.

Summary.

1. Plav is a floating fen confined in Rumania to the delta of the Danube. It is formed of reed, *Phragmites communis*, Trin., *β. flavescens*, Gren. & Godr.

2. Plav is built up almost entirely of *vertical* reed-rhizomes which, with the aid of their roots, retain much soil.

3. The detachment of the reed, that is the formation of Plav, takes place at a more or less definite stage of growth of the reed. Essential factors to Plav-formation are :—

(*a*) That the death of the basal rhizomes of the reed coincide with the swamp-stage of its growth ;

* The sub-dominant plant, in fact practically the only accompanying plant of "giant" reed Plav, *i. e.* newly risen Plav, is *Polystichum Thelypteris*, Roth. On drier Plav, the accompanying plants are mixed, though *Polystichum* is still sub-dominant (see the table on p. 265). Mosses occur only locally on Plav, which, in this respect, presents a contrast to fen where mosses abound. The only orchid I saw was *Epipactis palustris*, Crantz, and I only found it on newly risen Plav twice or three times. The absence of *Polystichum* from some Plavs, and the rarity of mosses and orchids, is possibly connected with the ease with which salt makes its appearance.

The Succession in the Balta of the Delta of the Danube.

The Succession of Species.		The Succession of the Vegetation.	
	=	? Steppe.	Xero-phytes.
? Salt-Marsh Plants (*Salicornia herbacea*, Linn., etc.).	=	? Climatic-Salt-Marsh.	Halo-phytes.
? Mixed Carices.	=	? Plav (Mixed Sedge).	Helophytes.
? *Cladium Mariscus*, Br., or Mixed Carices, *i. e*, the plants accompanying *Phragmites*.	=	? Plav (Sedge) or Plav (Mixed Sedge).	Helophytes.
Phragmites ; ? *Phragmites*	=	Plav (*Phragmites*) ; ? Plav (*Phragmites*).	Helophytes.
sometimes *Typha angustata*, Bory & Chaub. (*Phragmites* inhibited but not killed).		Plav (*Phragmites* and *Typha*).	Helophytes.
Phragmites communis, Trin., β. *flavescens*, Gren. & Godr.	=	sometimes *Typha* swamp. Swamp (*Phragmites*).	Helophytes.
Nymphæa alba, Linn., etc., etc. *Potamogeton pectinatus*, var. *pseudomarina*, A. Bennett, forma *salina*, Voch.	=	Submerged and floating-leaf aquatics.	Hydrophytes.
Open Water.		Open Water.	Hydrophytes.

The dotted arrows indicate that the succession indicated is the *probable* one.

The Succession in East Anglia.

The Succession of Species.		The Succession of the Vegetation.	
		? Heath.	Xero-phytes.
? *Quercus Robur*, Linn. (*Q. pedunculata*, Ehrh.). ↑	=	? Mesophytic Forest. ↑	Meso-phytes.
Alnus glutinosa, Gaertn. and *Salix cinerea*, Linn., or *Juncus obtusiflorus*, Ehrh., or *Molinia cærulea*, Moench. ↑	=	Carr- or *Juncus obtusiflorus*- or *Molinia*-Fen. ↑	Helophytes.
Mixed Carices and *Juncus obtusiflorus*, Ehrh. ↑	=	Mixed-Sedge-Fen. ↑	Helophytes.
Cladium Mariscus, R. Br., or Mixed Carices. ↑	=	Sedge-Fen. ↑	Helophytes.
Phragmites ↑	=	Reed-Fen (*Phragmites*). ↑	Helophytes.
→Sometimes *Typha angustifolia*, Linn.			
Phragmites communis, Trin. ↑			
Typha angustifolia, Linn. ↑	=	Reed-Swamp. ↑	Helophytes.
Scirpus lacustris (practically only in the Broads of the River Ant). ↑			
Nymphæa alba, Linn., etc. ↑			
Potamogeton pectinatus, Linn. ↑	=	Submerged and floating-leaf aquatics. ↑	Hydrophytes.
Open Water.		Open Water.	Hydrophytes.

Breydon Horsey, Norfolk. (bracket: Mixed Carices … Open Water)

The Succession along the Danube in Rumania in the Region of High Floods.

? Pasture.	? Mesophytic Forest.
↑	↑
Reed Thicket.	→Prundoae (in the Somova Plexus near Tulcea).
↑	
Reed-Swamp or Willow-forest.	
↑	
Submerged and floating-leaf plants.	
↑	
Water.	

(*b*) That the water be deep enough to prevent the reed filling it completely; and

(*c*) That if there be floods, the amount of silt borne by them be small.

4. Change of level of the water or storms are probably almost always nécessary to effect final detachment.

5. The reed forming the Plav is probably succeeded by "sedge" (*Cladium*), or "mixed-sedge" (*Carices*), and finally by salt-marsh plants. The only competitor with the reed is *Typha* (*T. angustata*, Bory & Chaub., in the delta, and *T. angustifolia*, Linn., in the Norfolk Broads), but apparently it merely inhibits the growth of the reed for a short time.

6. East-Anglian fen and Plav are fundamentally similar, viz., in structure and in origin.

7. The reed-shoots of Plav vary strikingly in size (in the Norfolk Broads this is also the case, but the variation is less conspicuous). The change in size of the shoots is regarded, in this paper, as a progressive morphological change, senescence which precedes the death of the reed.

8. The reed-shoots are regarded as building up a more or less definite whole—the reed major unit or reed-soma; and the reed-shoots themselves as the minor units or individuals.

9. The major unit is regarded as the total vegetative output which one fertilized cell is capable of initiating, and the minor unit as that portion of the major unit which is able to produce a replica of the specific soma of the major unit.

10. Major and minor individuals are regarded as fundamental units in botany, the former as a constant, its mass as the measure of specific vital energy. The major individual, however, does not necessarily develop its mass in one piece, hence it cannot, in general, be weighed directly.

11. Unlike the major, the minor individual is not a constant, for it varies in size. The variation in size, as already stated, is regarded as morphological and as testifying to the finite duration of the major unit, whose *absolute* age is thus indicated. In the reed the giant shoots are regarded as the lowest or morphologically juvenile branches of a vast branch-system the first and final branches of which do not co-exist.

12. "Vegetative *reproduction*" is regarded, in essence, as *growth of the major unit or soma*, and as taking place through the multiplication of the minor individuals.

APPENDIX A.

Grind or *Gradá* *: according to the fishermen a high spot of firm soil situated in the Balta. Grinds are, in fact, Balta islands of various shapes, sizes, heights, and soils. Most of them, for instance the *grindul Malului*

* Dr. Antipa devotes a section of his book, pages 100–113, to grinds. The account which follows is to a great extent an abridgment of his description.

(the natural river embankment), are narrow strips which extend for many miles along the water-courses (see Map, Pl. **25**), but others, such as Letei and Caraorman, are more or less fan-shaped (only a few of the existing grinds are shown on the maps). Some grinds, Letei and Caraorman for example, are never flooded, others are flooded annually, and others again are exposed only when the river is very low. Some are not known by name, whereas Letei and Caraorman possess several distinct villages, are cultivated and covered in places by sparse natural forest (see Appendix E, p. 283). The soils forming the grinds are river-, sea- and wind-borne, and mostly recent. Some, however, are composed of upland soil, loess, as the grindu Chiliei, for example, which is steppe like much of the country surrounding the delta, having been cut off from the upland by the river. The loess grinds correspond to the holmes of the Norfolk Broads district, river islets of upland soil (glacial loams, sands and clays). The grinds can roughly be classified as follows :—

(1) Grinds of river-deposited soils, the *grindul Malului* for example.

(2) Grinds of sea-drifted material, of which numerous examples exist between Lake Razim and the village of St. George. These are low, narrow sand-banks running parallel to the coast-line. Some of them are almost entirely composed of shells, in the main of whole shells near the sea, and of broken shells further inland. The present beach consists almost entirely of shells and is in some places, as for instance near Portiţa [Portitsa], cut back straight down by the waves. In such places the stratification into narrow bands of coarse and fine shells respectively is well shown.

The most abundant beach-forming shells are *Cardium edule*, Linn., and *Corbulomya mediterranea*, Costa; and *Mytilus edulis*, Linn., and *Nassa reticulata*, Deshayes, are also common. In places where freshwater streamlets issue from the Balta, dead shells of *Planorbis corneus*, Linn., and *Vivipara vivipara*, Sc., are abundant. *Balanus improvisus*, Darwin, is very often attached to *Corbulomya* *.

With these marine-formed grinds, long narrow and shallow salt lagoons, called Zatons, often alternate. The sea still continues to give rise both to new grinds and to new Zatons. For instance, in front of the Zatons marked Vechiu (old) and Nou (new) on Dr. Antipa's map, a fresh Zaton somewhat to the south-west of Zatonul Nou is to be looked for in the near future. The sea does not break on the beach there, but on a sand-bank—the future grind—still covered by water and indicated by the wreck of a small boat as well as by the line of breakers ; between this underwater bank and the present beach lies the Zaton of the future.

(3) Grinds formed of wind-blown sand. These grinds are practically all composite in character as regards soil. They are certainly formed in

* I am indebted to Mr. J. C. Robson, of the British Museum (Natural History), for kindly naming the Mollusca.

part of sea- or river-borne sediments, and Letei and Caraorman, for instance, have possibly been old land-surfaces *.

The grindu Sărăturile, north of St. George, is an interesting example of a composite grind. It is at present being covered by blown-sand, but its former origin is revealed by the few living remnants of the past salt-marsh vegetation, *Statice Gmelini*, Willd., and *Juncus maritimus*, Sm., for example, which project through the blown-sand. Here and there lagoon-deposited soils are present; that is to say, thin layers of very fine bluish silt, and to them the hardness and comparative goodness of the track across this sandy grind is probably due. The foundation of this grind is certainly in places marine.

APPENDIX B.

The Willow Forest of the Danube in Rumania.

A fringing willow forest consisting chiefly of *Salix alba*, Linn., is characteristic of the banks of the Danube practically up to Tulcea; beyond, it ceases, except for a few large scattered trees along the St. George Chatal and for a few woods along the Stari Stambul fork of the Chilia Chatal.

These fringing woods are narrow and more or less band-shaped and, in general, the trees are grouped together according to size, that is to say, the trees of the different groups are more or less of an age. Thus the later and earlier formed portions of the islands of the Danube can often readily be distinguished by the different sizes of the trees.

These characteristics apparently follow from the practice of turning out horses and cattle to pasture on the embankments when the Danube is low. The animals destroy almost all the seedlings on the bank, but those scattered in the river manage to escape, even though the cattle enter the water when the weather is hot (see Pl. **23**. fig. 2). Thus it is that the willow forest remains a narrow band, and does not die out along the banks of the Danube, but arises again and again as a fresh narrow band in front of the old one which in time vanishes. Incidentally, of course, the young trees in the water hasten the formation of land.

The cattle and horses, as a matter of fact, do not confine their attentions to tree seedlings, but apparently to a great extent determine the herbaceous vegetation of the embankments and islands of the Danube in Rumania. The most numerous plants are unpalatable ones, for example: *Althæa officinalis*, Linn., *Lythrum Salicaria*, Linn., *Bidens tripartita*, Linn., *Senecio tomentosus*, Host, *Xanthium spinosum*, Linn., *Myosotis palustris*, Roth, *Symphytum officinale*, Linn., *Convolvulus sepium*, Linn., *Mentha aquatica*, Linn., *Urtica dioica*, Linn., *Euphorbia salicifolia*, Host, and coarse hairy grasses. The dewberry, *Rubus cæsius*, Linn., is also very abundant, but nearly all the tops of its shoots are bitten off, only the lower hard and prickly parts of the plant remaining. I regret that the time at my disposal prevented me from preparing a complete list of this characteristic and interesting vegetation.

* See Antipa, pages 103–104, *op. cit.*

APPENDIX C.

The Tussock-Form of the Reed in the Norfolk Broads.

As already stated, the tussock-form of the reed was first observed on the river Yare, in the Broads of Surlingham and Strumpshaw. The formation of conspicuous tussocks there, as compared with other places in the Broads, is, I think, due to a series of special circumstances which have caused the tussock-form of growth to predominate over the creeping (see p. 248).

The tussocks on the Yare apparently result from horizontal immobility. They are situated along a narrow and, for the Broads, deep channel which passes through Surlingham fen and connects the few tiny broads still remaining. The water in this channel is in some places as much as 6 feet (1·8 m.) in depth at high tide, a depth too great for horizontal rhizomes to invade. Further, if a shoot happens to invade a shallower spot in the channel, it is, as a rule, eventually cut off, as the channel is kept open for rowing boats.

In a single summer, *Glyceria aquatica*, Sm., which edges most of the channels and broads of the Yare, with its trailing branches almost covers the Surlingham channel, which is almost lost to sight just before the annual cutting, whilst on the landward side, *Glyceria* also prevents *Phragmites* from extending its range.

Thus *Phragmites* is effectually prevented from spreading horizontally, the formation of vertical shoots being alone possible; hence apparently the extremely conspicuous tussocks of Surlingham (see Pl. **22**. fig. 1).

APPENDIX D.

The lists of plants of the Norfolk Broads and of the Delta of the Danube which follow are very small ones, and are to be regarded only as more or less typical *samples* of the floras of these two regions. In the delta obviously many more species remain to be discovered, since *Cladium Mariscus*, R. Br., and *Naias marina*, Linn., both frequent species, are recorded here as new for the Dobrogea, and as regards the Norfolk Broads the preparation of really adequately arranged lists has hardly begun. The East Anglian broads and rivers are apparently far richer in water-loving plants than the Danube in Rumania.

The nomenclature followed here is that of Hooker's * third edition for the British plants, and of Grecescu's Conspectul † for the Rumanian. In most cases I possess the exsiccata of the Rumanian plants used for identification.

* Hooker, J. D., "The Student's Flora of the British Islands," Third Edition, 1884.
† Grecescu, D., "Conspectul Florei României," 1898.

My thanks are due to a number of specialists who very kindly identified plants, viz.:—Mr. A. Bennett, *Utricularia* and *Potamogeton*; Mr. H. N. Dixon, the mosses of the delta of the Danube, and Mr. J. W. H. Johnson, the mosses of the Norfolk Broads; Mrs. Gregory, *Viola*; Mr. James Groves, the Characeæ of the delta, and the late Mr. Henry Groves, the Characeæ of the Norfolk Broads; the Rev. E. F. Linton, *Salix*; Dr. C. E. Moss, *Ranunculus* (§ *Batrachium*) and *Salicornia*; Mr. C. E. Salmon, *Statice*, and Mr. A. J. Wilmott, *Atriplex* and *Fraxinus*; also the Staff at the British Museum (Nat. Hist.) and at Kew. I wish to thank Dr. C. E. Moss and Mr. A. J. Wilmott in particular for much help with the general naming. As regards new records for Rumania and the Dobrogea, I have consulted Grecescu *, Brandza †, and Panţu ‡. If a plant was not mentioned in these works, I have taken it to be new for these places. Below I give a list of these new records. For the addition of *Utricularia minor*, Linn., and *Scirpus littoralis*, Schrad., to the Rumanian list, Mr. P. Enculescu and I are jointly responsible.

The symbols denoting frequency (within the association) I have borrowed from Mr. Tansley §. They are:—

d = dominant, ld = local dominant, lsd = locally sub-dominant, a = abundant, la = locally abundant, f = frequent, o = occasional, r = rare, vr = very rare.

Plants of the Delta of the Danube.

I.—Balta.

The Plants of Plav.

Ranunculus Lingua, *Linn.*	o	Sonchus arvensis, *Linn.*, β. uliginosus, *Simonk.* = Sonchus uliginosus, *Bieb.*!	f
Nasturtium officinale, *R. Br.*	f	Myosotis palustris, *Roth*	f
Lythrum Salicaria, *Linn.*	f	Convolvulus sepium, *Linn.*	f
Epilobium hirsutum *a*, *Linn.*	f	Solanum Dulcamara, *Linn.*	f
Cicuta virosa, *Linn.*	f	Mentha aquatica, *Linn.*	f
Apium graveolens, *Linn.*	f	Lycopus europæus, *Linn.*	f
Sium latifolium, *Linn.*	f	Stachys sp.	o
S. lancifolium, *Bieb.* (It appears to me to be *Sium angustifolium*, Linn.)	f	Scutellaria galericulata, *Linn.*	f
Galium palustre, *Linn.*	f	Lysimachia vulgaris, *Linn.*	f
Eupatorium cannabinum, *Linn.*	f	Samolus Valerandi, *Linn.*	f
Pulicaria dysenterica, *Gaertn.*	lsd	Polygonum tenuiflorum, *Presl*	o
Bidens tripartita, *Linn.*‖	f	Urtica dioica, *Linn.*	f
Cirsium sp.	r		

* Grecescu, D., "Conspectul Florei României."

† Brandza, D., "Flora Dobrogei," Bucharest, 1898.

‡ Panţu, Zach. C., "Flora Bucureştilor."

§ Tansley, A. G., "Types of British Vegetation," Cambridge, 1911.

‖ Around the channel of Filipoiu (the Balta of Brăila) I found the Lipovan fishermen making tea with this plant. I was informed that *Mentha* is often used for the same purpose.

The Plants of Plav (con.).

Salix cinerea, *Linn.* (probably)	o
S. grandifolia, *Seringe*	o
Populus alba, *Linn.*	vr
Epipactis palustris, *Crantz*	vr
Phragmites communis, *Trin.*, β. flavescens, *Gren. & Godr.* = Arundo isiaca, *Sieb.* (The most abundant and widely-spread plant in the delta.)	d
Typha latifolia, *Linn.*	o
T. angustata, *Bory & Chaub.*	ld
Cladium Mariscus, *R. Br.**	ld
Carex riparia, *Curt.*	lsd
C. paniculata, *Linn.*	f
Polystichum Thelypteris, *Roth* = Nephrodium Thelypteris, *Desv.*	lsd
Hypnum aduncum, *Hedw.*, var. polycarpa (*Bland.*)	o
H. polyganum, *Schimp.*, var. stagnatum, *Wits.* (often climbs a short way up the *Phragmites* and *Typha* stems)	o
H. cuspidatum, *Linn.*	o

Salt-marsh Plants on Plav.

Apium graveolens, *Linn.*	f
Aster Tripolium, *Linn.*	la
Suæda maritima, *Dumort.*	la
Salicornia herbacea, *Linn.*, forma stricta, *Moss & Salisb.*	la
Atriplex latifolia, *Wahlenb.* = A. hastata, *Moq.-Tand.*	f
Juncus Gerardi, *Lois.*	la

Aquatic Plants.

Ranunculus trichophyllus, *Chaix*, var. rigida	o
R. Lingua, *Linn.*	o
Nymphæa alba, *Linn.*	la
Nuphar luteum, *Sm.*	la
Aldrovanda vesiculosa, *Linn.*	f
Trapa natans, *Linn.*	la
Myriophyllum verticillatum, *Linn.*	a
M. spicatum, *Linn.*	a
Limnanthemum nymphoides, *Link*	f
Utricularia vulgaris, *Linn.*	f
U. minor, *Linn.*	o
U. neglecta, *Schmid.*	o
Ceratophyllum demersum, *Linn.*	va
Butomus umbellatus, *Linn.*	o
Hydrocharis Morsus-ranæ, *Linn.*	a
Stratiotes Aloides, *Linn.*	ld
Sagittaria sagittæfolia, *Linn.*	o
Juncus maritimus, *Lam.* (salt water)	ld
Scirpus maritimus, *Linn.*	ld
Scirpus Holoschœnus, *Linn.*	o
S. littoralis, *Schrad.*	o
Cladium Mariscus, *R. Br.*	o
Phragmites communis, *Trin.*, β. flavescens, *Gren. & Godr.*	ld
Typha angustata, *Bory & Chaub.*	ld
Sparganium ramosum, *Huds.*	f
Potamogeton lucens, *Linn.*	f
P. lucens, *Linn.*, β. acuminatus, *Reichb.*	f
P. perfoliatus, *Linn.*	o
P. pectinatus, *Linn.* (probably)	va
P. pectinatus, var. pseudomarina, *A. Bennett*, forma salina, *Voch*	va
Naias marina, *Linn.*	f
Lemna trisulca, *Linn.*	a
L. minor, *Linn.*	f
Salvinia natans, *Hoffm.*	a
Chara sp., *cf.* C. baltica, *Brugel*	la
Lychnothamnus stelliger, *Braun*	f

* The fishermen call *Cladium* the rizak of the land, and *Stratiotes* the rizak of the water (for the rizak see Pl. **18**, fig. 2 & Pl. **20**).

II.—Grinds.

Land Plants *.

Delphinium Consolida, *Linn.*	a
Berberis vulgaris, *Linn.*	f
Helianthemum vulgare, *Gaertn.*	o
Dianthus polymorphus, *Bieb.*	o
Gypsophila trichotoma, *Wender.*	f
Silene Otites, *Sm.*	o
Linum austriacum, *Linn.*	o
Vitis vinifera, *Linn.*	f
Rhamnus Frangula, *Linn.*	f
Medicago falcata, *Linn.*	f
Melilotus alba, *Desv.*	f
Rosa sp.	o
Pyrus communis, *Linn.*	o
Cratægus monogyna, *Jacq.*	o
Seseli sp.	?
Asperula sp.	?
Scabiosa ucranica, *Linn.*	f
Erigeron acre, *Linn.*	a
Artemisia Santonicum, *Linn.* (agg.) = A. maritima, β. patens, *Neilr.*	a
Senecio erucæfolius, *Linn.*	o
Centaurea spinulosa, *Rochel*	f
C. arenaria, *Bieb.*	f
Cichorium Intybus, *Linn.*	o
Chondrilla juncea, *Linn.*	o
Crepis rhœadifolia, *Bieb.*	o
Hieracium præaltum, *Vill.*	o
Xanthium Strumarium, *Linn.*	a
X. macrocarpum, *DC.*	f
Ligustrum vulgare, *Linn.*	o
Fraxinus excelsior, *Linn.*, β. oxycarpa, *Willd.*	f
F. Pallisæ, *Wilmott*	f
Periploca græca, *Linn.*	f
Cynanchum acutum, *Linn.*	f
Onosma arenarium, *Waldst. & Kit.*	f
Echinospermum Lappula, *Lehm.*	f
Verbascum Blattaria, *Linn.*	o
Linaria genistifolia, *Mill.*	o
Veronica spicata, *Linn.*	o
Statice Gmelini, *Willd.*	f
S. caspia, *Willd.* = S. bellidifolia, *DC.*	o
Plantago arenaria, *Waldst. & Kit.*	f
Corispermum nitidum, *Kit.*	o
Polygonum arenarium, *Waldst. & Kit.*	f
Hippophaë Rhamnoides, *Linn.*	f
Ulmus campestris, *Linn.*	o
Loranthus europæus, *Linn.* (on *Quercus Robur*)	f
Euphorbia Paralias, *Linn.*	a
Quercus Robur α, *Linn.*	f
Salix rosmarinifolia, *Linn.*	o
Populus alba, *Linn.*	a
P. tremula, *Linn.*	o
P. nigra, *Linn.*	o
Ephedra distachya, *Linn.*	o
Asparagus sp.	?
Allium paniculatum, *Linn.*	o
Cyperus pannonicus, *Jacq.*	o
Tragus racemosus, *Scop.*	o
Panicum Crus-galli, *Linn.*	o
Crypsis aculeata, *Ait.*	o
Cynodon Dactylon, *Pers.*	a
Andropogon Ischæmum, *Linn.*	o
Erianthus strictus, *Bluff & Fingerh.*	o
Eragrostis poæoides, *Beauv*	o

New Records for Rumania.

Malva sylvestris, var. eriocarpa, *Boiss.* (Haussknecht in Iter græcum)	Serpent Island (Black Sea).
Fraxinus Pallisæ, *Wilmott*	Letei and Caracrman (new to science).
Utricularia minor, *Linn.* (Recorded by P. Enculescu and M. Pallis.)	More or less everywhere in delta.
U. neglecta, *Schmid.*	Between Roșuleț and Caraorman.
Polygonum tenuiflorum, *Presl*	Between Roșu and Caraorman (on Plav).
Euphorbia Paralias, *Linn.*	Common on grinds everywhere (sand).
Scirpus littoralis, *Schrad.* (Recorded by P. Enculescu and M. Pallis.)	Delta.
Typha angustata, *Bory & Chaub.*	Round Roșuleț.

* This list refers chiefly to the islands of Letei and Caraorman. Trees are infrequent on the smaller grinds.

New Records for the Dobrogea.

Cladium Mariscus, *R. Br.*	Between Roșuleț and sea.
Naias marina, *Linn.*	Common in delta.
Erianthus strictus, *Bluff & Fingerh.*	On grind of Letei—found once.

Plants of the Norfolk Broads.

I.—*Fen Plants.*

Thalictrum flavum, *Linn.* (agg.)	la
Ranunculus Flammula, *Linn.* (agg.)	f
Caltha palustris, *Linn.* (agg.)	f
Nasturtium officinale, *R. Br.*	f
Cardamine pratensis, *Linn.*	a
C. amara, *Linn.*	f
Viola palustris, *Linn.*	la
Lychnis Flos-cuculi, *Linn.*	f
Sagina nodosa, *E. Mey.*	o
Hypericum tetrapterum, *Fries*	f
H. elodes, *Huds.*	o
Rhamnus catharticus, *Linn.*	f
R. Frangula, *Linn.*	la
Lathyrus palustris, *Linn.*	f
Spiræa Ulmaria, *Linn.*	a
Potentilla Comarum, *Nestl.*	f
P. Tormentilla, *Scop.*	a
Rosa canina, *Linn.* (agg.)	o
R. arvensis, *Huds.* (agg.)	o
Cratægus Oxyacantha, *Linn.* (agg.)	o
Parnassia palustris, *Linn.*	f
Ribes rubrum, *Linn.*	o
R. nigrum, *Linn.*	o
Drosera rotundifolia, *Linn.*	la
D. anglica, *Huds.*	r
Lythrum Salicaria, *Linn.*	a
Epilobium hirsutum, *Linn.*	f
Hydrocotyle vulgaris, *Linn.*	va
Cicuta virosa, *Linn.*	o
Sium latifolium, *Linn.*	f
S. angustifolium, *Linn.*	f
Œnanthe fistulosa, *Linn.*	a
Œ. Lachenalii, *Gmel.*	a
Angelica sylvestris, *Linn.*	a
Peucedanum palustre, *Moench*	f
Viburnum Opulus, *Linn.*	f
Galium palustre, *Linn.* (agg.)	a
G. uliginosum, *Linn.*	a
Valeriana dioica, *Linn.*	a
V. officinalis, *Linn.* (proper)	a
Scabiosa Succisa, *Linn.*	f
Eupatorium cannabinum, *Linn.*	f
Cnicus palustris, *Hoffm.*	f
Cnicus pratensis, *Willd.*	f
Erica Tetralix, *Linn.*	la
E. cinerea, *Linn.*	la
Calluna vulgaris, *Salisb.*	la
Pyrola rotundifolia, *Linn.* (proper)	r
Lysimachia vulgaris, *Linn.*	f
L. Nummularia, *Linn.*	f
Anagallis tenella, *Linn.*	o
Samolus Valerandi, *Linn.*	f
Ligustrum vulgare, *Linn.*	o
Fraxinus excelsior, *Linn.*	o
Menyanthes trifoliata, *Linn.*	f
Myosotis palustris, *With.* (proper)	f
Convolvulus sepium, *Linn.*	f
Solanum Dulcamara, *Linn.*	o
Rhinanthus Crista-galli, *Linn.*	f
Pedicularis palustris, *Linn.*	f
Mentha aquatica, *Linn.* (agg.)	f
Lycopus europæus, *Linn.*	f
Scutellaria galericulata, *Linn.*	f
Rumex Acetosa, *Linn.*	f
R. Acetosella, *Linn.*	f
Myrica Gale, *Linn.*	la
Betula alba, *Linn.*, subsp. glutinosa, *Fries*, var. pubescens	f
Alnus glutinosa, *Gaertn.*	f
Quercus Robur, *Linn.*	o
Salix Caprea, *Linn.*, subsp. cinerea, *Linn.*	f
S. repens, *Linn.*	f
Liparis Loeselii, *Rich.*	r
Listera ovata, *R. Br.*	o
Epipactis palustris, *Sw.*	f
Orchis latifolia, *Linn.*	o
O. latifolia, *Linn.*, subsp. incarnata, *Hook. f.*	a
Juncus obtusiflorus, *Ehrh.*	ld
Luzula campestris, *Willd.*, var. erecta, *Desv.*	f
Alisma ranunculoides, *Linn.*	o
Triglochin palustre, *Linn.*	o
Eriophorum polystachion, *Linn.* (agg.)	la
Schœnus nigricans, *Linn.*	ld

Fen Plants (con.).

Cladium Mariscus, *R. Br.*	ld
Carex pulicaris, *Linn.*	f
C. paniculata, *Linn.* (proper)	f
C. paniculata, *Linn.*, subsp. paradoxa, *Hook. f.*	f
C. stricta, *Good.*	a
C. filiformis, *Linn.*	o
C. flava, *Linn.* (agg.)	f
C. vesicaria, *Linn.*	o
C. ampullacea, *Good.*	o
C. Pseudocyperus, *Linn.*	o
C. riparia, *Curt.*	a
Phalaris arundinacea, *Linn.*	ld
Anthoxanthum odoratum, *Linn.*	a
Agrostis canina, *Linn.*	la
A. vulgaris, *With.* (agg.)	a
A. alba, *Linn.*	f
Calamagrostis lanceolata, *Roth*	ld
Holcus lanatus, *Linn.*	a
H. mollis, *Linn.*	o
Triodia decumbens, *Beauv.*	l
Phragmites communis, *Trin.*	ld
Molinia cœrulea, *Moench*	ld
Briza media, *Linn.*	f
Poa pratensis, *Linn.*	la
P. trivialis, *Linn.*	la
Glyceria aquatica, *Sm.*	ld
Festuca elatior, *Linn.*	a
Nardus stricta, *Linn.*	la
Nephrodium cristatum, *Rich.*	o
N. cristatum, var. uliginosa, *Baker* = Lastrea uliginosa, *Newman*	o
N. Thelypteris, *Desv.* = Polystichum Thelypteris, *Roth*	lsd
Ophioglossum vulgatum, *Linn.*	f
Sphagnum cymbifolium, *Ehrh.*	la
S. squarrosum, *Pers.*	la
S. intermedium, *Hoffm.*	la
Polytrichum commune, *Linn.*	la
Aulocomnium palustre (*Linn.*), *Schwaegr.*	la
Hypnum cuspidatum, *Linn.*	va
H. scorpioides, *Linn.*	la
H. giganteum, *Schimp.*	la

II.—*Aquatic Plants.*

Ranunculus circinnatus, *Sibth.*	a
R. Lingua, *Linn.*	o
Nuphar luteum, *Sm.*	va
Nymphæa alba, *Linn.*	va
Hippuris vulgaris, *Linn.*	va
Myriophyllum verticillatum, *Linn.*	va
M. spicatum, *Linn.*	va
Callitriche spp.	a
Apium inundatum, *Reichb.*	r
Œnanthe Phellandrium, *Lam.*	f
Hottonia palustris, *Linn.*	ld
Utricularia vulgaris, *Linn.* (proper)	ld
U. intermedia, *Hayne*	o
U. minor, *Linn.*	o
Polygonum amphibium, *Linn.*	o
Rumex Hydrolapathum, *Huds.*	f
Ceratophyllum demersum, *Linn.* (agg.)	ld
Hydrocharis Morsus-Ranæ, *Linn.*	va
Stratiotes Aloides, *Linn.*	ld
Elodea canadensis, *Michx.*	ld
Sparganium ramosum, *Huds.*	a
S. natans, *Linn.*	r
Typha latifolia, *Linn.*	o
T. angustifolia, *Linn.*	ld
Lemna minor, *Linn.*	va
L. trisulca, *Linn.*	va
L. gibba, *Linn.*	l
L. polyrhiza, *Linn.*	l
Alisma Plantago, *Linn.*	f
Sagittaria sagittifolia, *Linn.*	a
Butomus umbellatus, *Linn.*	o
Potamogeton natans, *Linn.*	va
P. lucens, *Linn.*	a
P. lucens, var. acuminatus, *Reichb.*	f
P. prælongus, *Linn.*	a
P. perfoliatus, *Linn.*	a
P. pusillus, *Linn.*, var. tenuissima, *Koch*	la
P. pectinatus, *Linn.*, subsp. flabellatus, *Hook. f.*	va
Zannichellia palustris, *Linn.* (agg.)	o
Naias marina, *Linn.*	r
Scirpus lacustris, *Linn.*	la
Cladium Mariscus, *R. Br.*	f
C. paniculata, *Linn.*	f
Carex stricta, *Good.*	f
C. riparia, *Curt.*	f
Phragmites communis, *Trin.*	ld
Azolla filiculoides, *Lam.*	ld
Chara aspera, *Willd.*	va
C. hispida, *Linn.*	va
C. polyacantha, *A. Br.*	va
Lychnothamnus stelliger, *A. Br.*	o
Fontinalis antipyretica, *Linn.*	f
Ricciocarpus natans, *Corda*	o
Cladophora ægagropila, *Kuetz.*	ld
Enteromorpha intestinalis, *Link.*	f

APPENDIX E.

FRAXINUS, sp. n.

The two districts of the area under consideration in which ash-trees occur are the "grinds" of Letei and Caraorman (see p. 275). They grow rather sparsely, forming, with other trees, a semi-woodland. Some of them are referable to *F. oxycarpa*, Willd. [Elwes and Henry, 'The Trees of Great Britain and Ireland,' iv. p. 882 (1909); Schneider, Handb. d. Laubholzkunde, ii. p. 833 (1912)]; others are absolutely glabrous, even lacking the tuft of hairs at the base of the midrib which is characteristic of that species. These appear to come under the *F. angustifolia*, Vahl, of the same works, but since the material contains variations in other directions, it is not safe definitely to refer them to that western Mediterranean species. The material is inadequate to settle whether they are of hybrid origin or possibly abnormally glabrous specimens of *F. oxycarpa*. Other closely related glabrous species grow in Asia Minor, and the relationships of these plants require further investigation on the spot.

The bulk of the material collected, however, consists of extremely pubescent specimens, here described as a species new to science. The extremely peculiar plant described as var. γ has not been kept distinct owing to the absence of fruits and the presence of other peculiar forms in the material under discussion. It also requires further study in the field. Since it was at first regarded as possible that the vars. α and β, which are in leaf-characters somewhat intermediate between var. γ and *F. oxycarpa*, might be the result of hybridisation between those two forms, more material, much more complete in respect of the fruit, was obtained through the kindness of Mr. George Marshall, of Sulina. Upwards of fifty packets were received, each collected from a different tree, excluding two cases of mixed glabrous and hairy specimens which are not likely to come from the same plant.

These packets were sorted first into glabrous and hairy piles. From the latter were separated twenty-eight packets, from which the following description was written, leaving several extremely variable specimens, some with leaflets broad, some large and thin, some entire, some with extremely large teeth. Two had long narrow fruits; one had the fruits broad and very emarginate except a single one broader than any other ash-fruit I have seen. Since most of these variations also occur on the glabrous plants, they may well be due to segregation from hybrids, while the possibility of the occurrence of *F. parvifolia*, whose home, South Russia, is not far distant, is not to be excluded. It is obvious that the Ash-trees of the neighbourhood have been neglected, and that there are many questions to be answered by careful field-work.

The remainder of the material, which is now to be described, was divided into those (9) with fewer smaller and narrower leaflets, and those (19) with more numerous larger and broader leaflets. It was then seen that the fruits of these two series were extremely different, and then again noticed that the former came entirely from Letei, while the latter came entirely from Caraorman. Owing to the relatively large proportion of unexplained variation occurring in the material, these have not been described as distinct species, though they may prove to be so. In the latter case, the plant from Letei should be regarded as the type of the species which is now described.

FRAXINUS PALLISÆ, *Wilmott*, nov. spec.

Arbor 30-metralis. Rami hornotini fusci, dense velutini, annotini cinerei, plerumque glabri. Gemmæ parvæ, fuscæ vel fusco-atræ, glabræ, rarissime pilo unico vel pilis duobus onustæ. Folia 5–9(–11)-foliolata; rhachis dense pubescens, supra canaliculata sulco juxta basim foliolorum aperto densissime pubescente; foliola lanceolata, terminalia in petiolum brevem attenuata, lateralia plerumque basi rotundata, sessilia vel subsessilia, omnia angustata vel subacuminata vel parum magis elliptica, argute vel mediocriter serrata (vel rare subintegra), utrinque præsertim vero subtus pubescentia, basi ad nervum medium densissime pubescentia. Racemi sparse hirti vel subglabri. Samara anguste elliptica vel elliptico-lanceolata, acuta, pistilli basi diu ornata, basim versus sparse hispida. Exstant varietates duæ quæ sunt fructibus perdistinctæ.

α. TYPICUS. Folia (11–)12–14(–16) cm. longa, 5–7(–9)-foliolata; foliola 50–64 mm. longa, (8–)13–17 mm. lata. Samara matura (37–)38(–39) mm. longa, (9–)10 mm. lata, elliptico-oblanceolata basi haud contorta, immatura (?) immixta parva, elliptico-ovata, 24 mm. longa, 7 mm. lata.

Letei, Dobrogea.

β. GYROCARPUS. Folia 15–21 cm. longa, (5–)7–9(–11)-foliolata; foliola quam in var. *typica* majora (50–)60–70 mm. longa, (14–)17–19 mm. lata, margine raro subintegra. Samara (40–)41(–42) mm. longa, 9 mm. lata, anguste elliptica, basi angulo recto contorta. Caraorman, Dobrogea.

Varietas (vel status) egregia, sed imperfecte nota :—

γ. ANGUSTIFOLIUS. Magis pubescens. Rami per duos annos velutini. Folia 5–7-foliolata; foliola peranguste lanceolata, terminalia 50–80 (modica 67) mm. longa, 7–13 (modica 96) mm. lata, 5·5–8·0 (modica 6·9)-plo longiora quam latiora, margine subintegra, utrinque velutina.

Caraorman, Dobrogea.

The species differs from *F. coriariæfolia*, Scheele, in the shape and size of the leaflets, which (in Herb. Mus. Brit.) have the upper surface very

sparsely hairy (described as glabrous by Scheele), with hairy midribs. The fruits are also different. It seems nearest related to *F. holotricha*, Koehne, especially in the sparsely pubescent fruit (though the fruit of the latter is unknown, the carpel is pubescent). But it does not agree with the specimens (from Spath's nursery !) growing in the Kew arboretum. The pubescence of these trees is not exactly the same, and the leaflets, correctly described as 9–13 to each leaf, are not of the same shape. It is not possible to give these wild specimens the same name as garden specimens of unknown origin which have never fruited, unless the agreement is absolute, although *F. holotricha* may be a garden hybrid of *F. Pallisæ* with some other species, which might explain its absence of fruit. It must be agreed that *F. holotricha* is nearer to *F. Pallisæ* than to any other described species of *Fraxinus*, but there the matter must be left until it is more completely known. Its pubescence distinguishes *F. Pallisæ* from any other Old World ash.

A. J. Wilmott.

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EXPLANATION OF THE PLATES.

The under-water portions of the reed and of Plav.

PLATE 11.

The rhizome portion of the shoots of "giant" reed, *Phragmites communis*, Trin. *β. flavescens*, Gren. & Godr. Roşuleţ. The etiolated portion of the rhizome lives in the mud; it has mud-roots—in this example slightly branched, and therefore somewhat intermediate in character between true mud- and water-roots. The green portion of the rhizome lives in the water and has water-roots, viz. roots branched to the 3rd degree, on which soil has already collected. Some of the internodes of the rhizomes measure about 4 cm. (about 1·5 inches) in diameter.

Plate 12.

A young giant-reed stool. Delta of the Danube. The tussock-portion measures about 0·4 m. (about 1 foot 4 inches). The photograph is taken against a door which measures about 1·65 m. (about 5 feet 3 inches). Some of the mud-roots are about 0·3 m. (about 12 inches) in length.

Plate 13.

A medium-sized stool of giant-reed. Delta of the Danube. About 0·95 m. (about 3 feet 2 inches), are shown in the photo. Tussock-portion about 0·3 m. (about 12 inches).

Plate 14.

Two pieces of the Sherneshenko Sahi Plav turned upside down, near Lake Roşuleţ. In the piece in the background the rhizomes are green as the light reaches the edge of Plav; algæ, *Vorticella*, *Dreissena*, etc. also coat them. The piece in the foreground is cut from the inside of the Plav, hence the etiolated rhizomes. The rhizomes curve round to the surface, that is to say, the Plav increases in size slightly by the growth of its edge. Many water-roots and much soil is shown in the photo.

Plate 15.

Section through giant-reed Plav, Nazaraou Rinok, Lake Roşuleţ. The length of the aerial portions of the shoot is about 5·15 m. (slightly over 17 feet). See Pl. **24**, section I. The door measures about 1·65 m. (about 5 feet 5 inches), and the Plav about 1·7 m. (about 5 feet 7 inches) in thickness. *That Plav is built up chiefly of vertical rhizomes shows clearly in this photo, as also the healthiness of the base of the Plav-layer.* The top layer of black soil just shows at the upper edge in the photo: in this soil *Polystichum Thelypteris*, Roth, is rooted.

Plate 16.

Section through slender ("*shitka*") reed Plav near Roşuleţ. The thickness of this Plav is about 1·5 m. (about 5 feet), and the length of the aerial portion of the reed is about 2 m. (about 6 feet $6\frac{3}{4}$ inches).

Plate 17.

An edge piece of the Sherneshenko Sahi Plav. The irregularity of disposition of the rhizomes is probably due to this piece having grown when the reed was floating, that is to say, when it was Plav.

The aerial portions of the reed and of Plav.

Plate 18.

Fig. 1.—Edge of a Plav of giant-reed, near Lake Roşu. The length of the aerial portion of the reed-shoots (the minor individuals) is about 4·5 m. (about 15 feet). There is much *Carex paniculata*, Linn., at the edge of this Plav.

Fig. 2.—The Ivan Mekitenko Plav. Its oldest portion is in the foreground and its younger portion formed of short giant-reed in the background. These two portions are sharply separated from each other, as shown in the photo.

Plate 19.

Fig. 1.—The surface of a giant-reed Plav. The shoots measure between 4·5–5 m. (15 to 16 feet) in height. Near Roşuleţ. The boy's height is about 1·4 m. (about 4 ft. 8 in.).

Fig. 2.—The surface of a Plav of short-slender reed. Near Roşuleţ. The shoots are aged minor individuals and measure about 2 m. (6 feet $6\frac{3}{4}$ inches) in height. The undergrowth is mixed, but *Polystichum Thelypteris*, Roth, is much the most abundant species.

Plate 20.

Fig. 1.—Giant-reed Plav near Lake Lumina. *Polystichum Thelypteris,* Roth, subdominant. Note the *rizak.*

Fig. 2.—A Plav of tall-slender reed. Near Balanova Sahi, near Lake Roşu. The height of the reed is about 3 m. (about 9 feet 10 inches). Note *rizak* (see p. 235).

Plate 21.

Fig. 1.—Distant view of "Schwimmende Inseln" in Lake Merhei M.

Fig. 2—"Schwimmende Inseln" at close range. Litcovu (Litcov) Canal. Between Carmen Silva and Litcov. *Polystichum Thelypteris,* Roth, subdominant. Swamp in the background with a *Polystichum* edge. In the water *Nymphæa alba,* Linn., *Stratiotes Aloides,* Linn., *Potamogeton natans,* Linn., etc.

The Norfolk reed and Fens.

Plate 22.

Fig. 1.—*Phragmites* stools in Strumpshaw Broad, River Yare, Norfolk. The reed is *Phragmites communis,* Trin., var. ?; *Typha latifolia,* and *Glyceria aquatica,* Wahlenb., are also present. The tree on the fen in the distance is *Fraxinus excelsior,* Linn.; there are also some sallows on the fen—probably *Salix cinerea,* Linn.

Fig. 2.—Sedge-fen at Breydon Horsey, Norfolk. *Cladium Mariscus,* R. Br., is dominant. The bush is *Salix cinerea,* Linn. The sand-hills show in the distance. July 21st, 1908.

The Balta in general.

Plate 23.

Fig. 1.—The reed thickets of the Danube above the delta close to Tulcea; view of the Danube valley, taken from the upland at Somova. *Salix alba,* Linn., is very abundant.

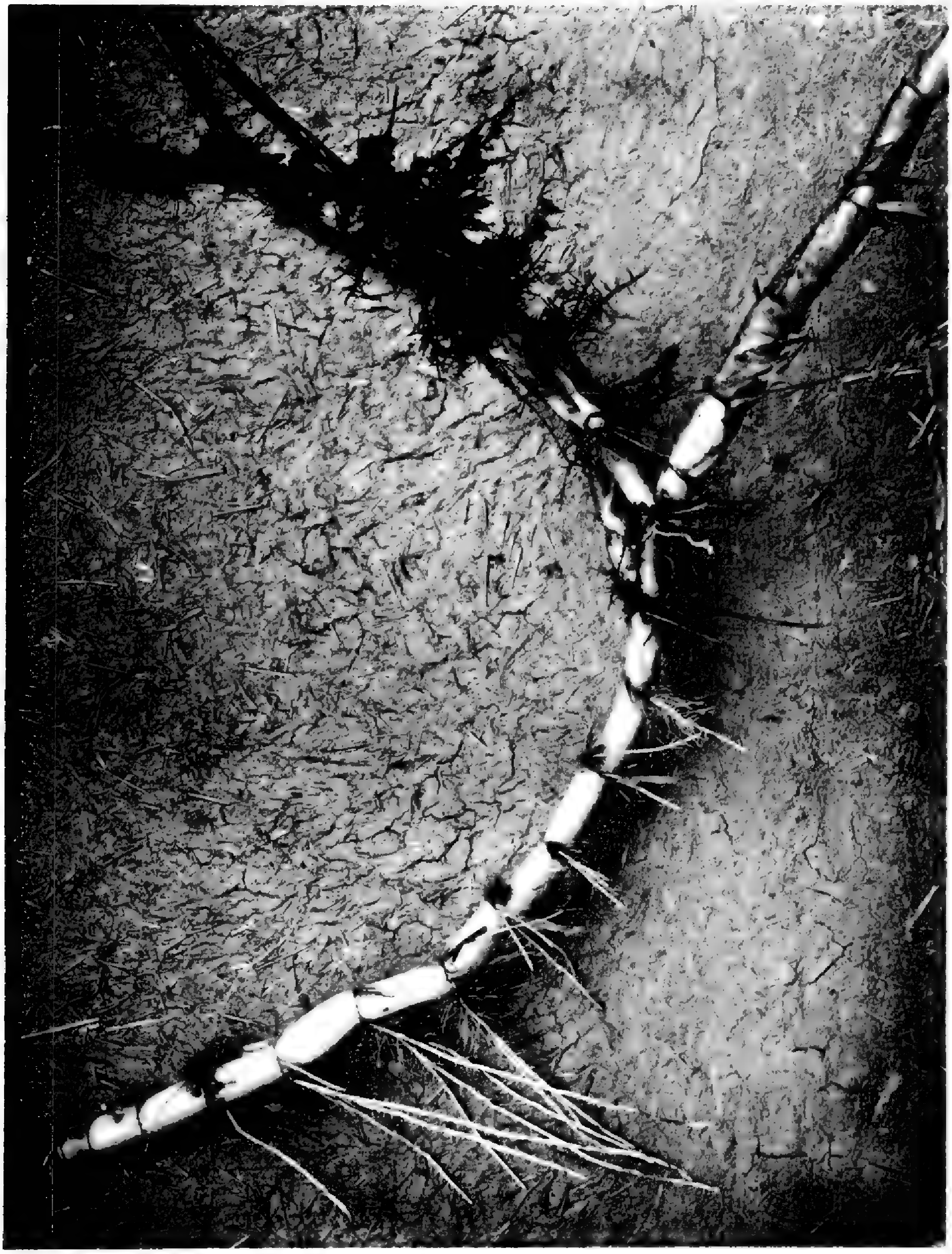
Fig. 2.—The beginning of a willow forest in the Danube north of Cernavoda (see Appendix B).

Plate 24.

DIAGRAMS.

Plavs of the Delta of the Danube (Sections I., II., & III.) *and of East Anglian Fen* (Section IV.). 1/40 natural size.

The diagrams of Plav are drawn to the water-level of September 28th, 1913 (=zero) (see footnote on page 238). The difference in level of the water between Sept. 6th and 28th (approximately low and high water of the Danube) was about 0·55 m. (about 1 foot 10 inches). The upper line (black) of the diagram is the water-level of Sept. 28th, zero, and the lower line (dotted) that of Sept. 6th. The short dotted line below the Plav shows the position of the base of the Plav on Sept. 6th. The ground-bed of the delta is a silver sand sometimes overlaid by a layer of fine *inorganic* ooze which varies in thickness. Above the sand or inorganic ooze, as the case may be, there is generally a layer of fluvio-lacustrine ooze, viz.: an ooze with a considerable proportion of organic matter, which has probably mostly been added *in situ* to the fine river-borne silt. Above this layer is the free water in which the Plav floats; the surface of the Plav rises a few centimetres above the water. The Plavs were sectioned with the rizak. An ordinary soil-borer about 20 feet (6·09 metres) in length was used in the fens for sounding, and for collecting small samples of ooze.



M.P. photo London Stereoscopic Co. Collo

STRUCTURE OF PLAV.

M P photo London Stereoscopic Co. Collo

STRUCTURE OF PLAV.

M.P photo
London Stereoscopic Co Coll.

STRUCTURE OF PLAV.

STRUCTURE OF PLAV.

M.P. photo London Stereoscopic Co. Collo

PALLIS

M.P. photo

London Stereoscopic Co. Collo.

STRUCTURE OF PLAV

M.P. photo

London Stereoscopic Co. Collo.

STRUCTURE OF PLAV.

M P. photo.

London Stereoscopic Co. Coll.

STRUCTURE OF PLAV.

Fig. 1

Fig. 2

M. P. phot. London Stereoscopic Co. Coll.

AERIAL PORTION OF PLAV.

Fig. 2

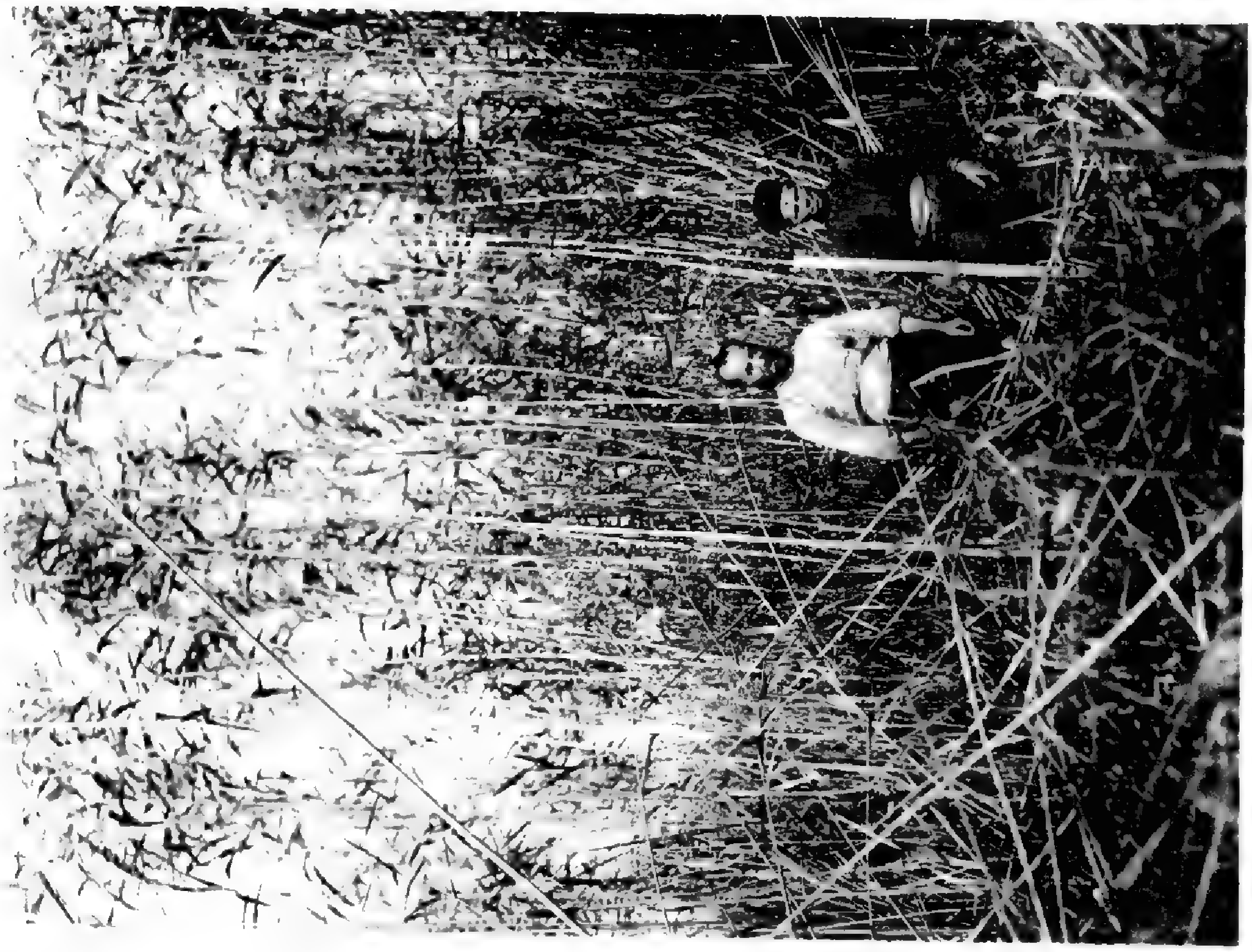


Fig. 1

GIANT- AND SHORT-SLENDER REED PLAVS

M P photo

London Stereoscopic Co.

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Fig. 1

Fig. 2

GIANT- AND TALL-SLENDER REED PLAVS.

M.P. photo

London Stereoscopic Co. Collo

Fig. 1

Fig. 2

M.P. photo

London Stereoscopic Co. Collo

FLOATING REED-ISLETS OF THE DANUBE.

Fig. 1

REED STOOLS IN NORFOLK.

Fig. 2

M P. photo

London Stereoscopic Co.

SEDGE-FEN AT BREYDON, IN NORFOLK

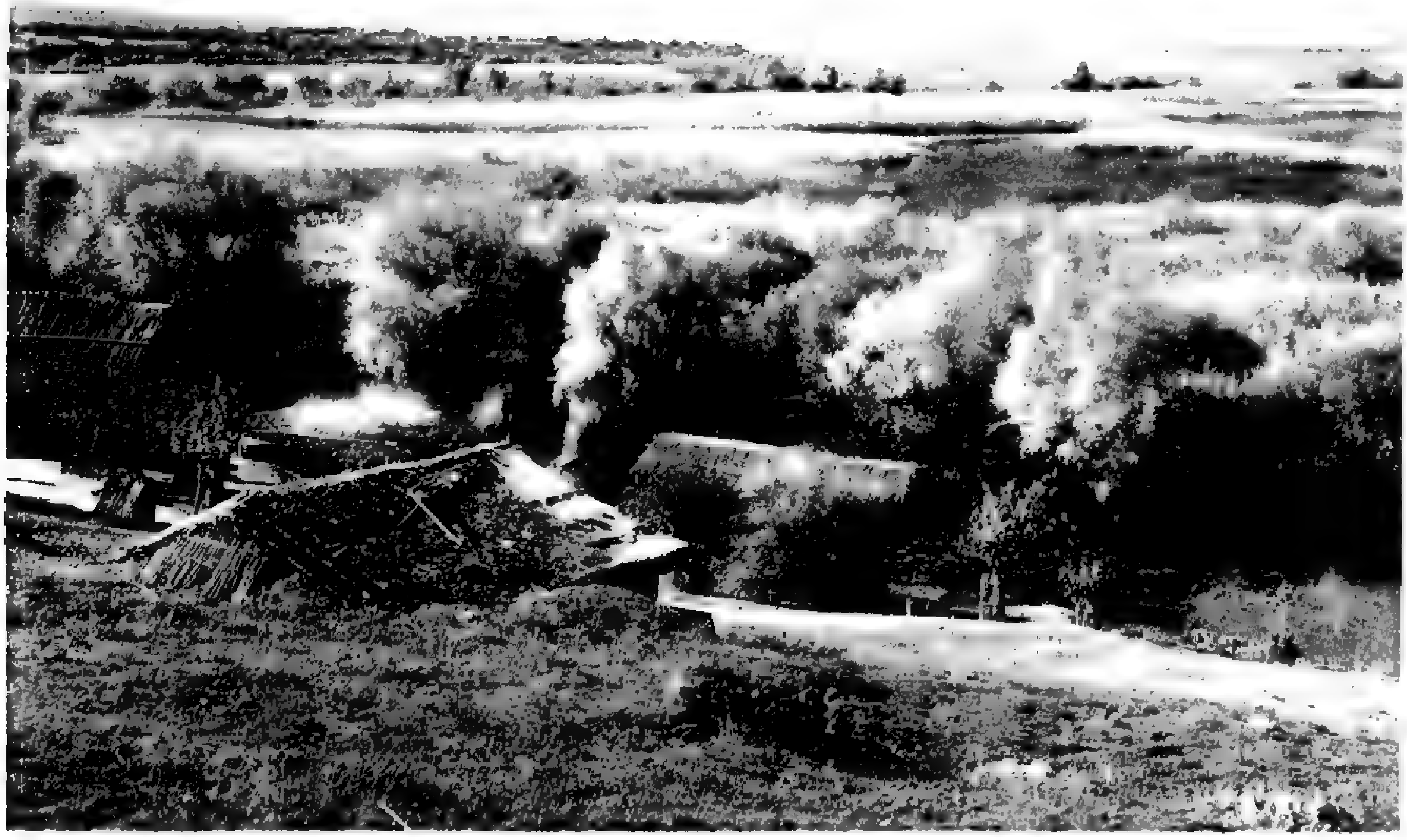

Fig. 1

THE REED THICKETS OF THE DANUBE.

Fig. 2

M.P. photo London Stereoscopic Co. Collo.

YOUNG WILLOW FOREST ON THE DANUBE.

Journ. Linn. Soc. Bot. Vol. XLIII. Pl. 24

M P. del.

SECTIONS OF PLAV OF THE DANUBE.

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SECTION I.

Phragmites Plav (*Phragmites communis*, Trin., *β. flavescens*, Gren. & Godr.). Nazaraou Rinok on Lake Roșuleț. The section was cut on Sept. 27th, 1913. The thickness of this Plav is about 1·55 m. (about 5 feet), and its surface rises about 4 cm. (about 1·5 in.) above that of the water. The depth to the sand, as measured from the surface of the Plav on Sept. 28th, was about 2·76 m. (about 9 feet).

This Plav is typical young reed-Plav. It consists of 3 *soil* layers. (1) A top layer of black, apparently highly organic soil, some 15 cm. (about 6 inches) in thickness. *Polystichum Thelypteris*, Roth, is rooted in this layer; it is practically the sole accompanying plant of young wet Plav. (See footnote on page 271 and Plate **20**. fig. 1.) (2) A layer, about 0·8 m. (about 2 feet 10 inches) in thickness, of relatively fine soil, partly organic, held by the branched roots and the rhizomes of *Phragmites*; and (3) A layer of relatively coarse soil, some 0·6 m. (close on 2 feet) in thickness, with a smaller organic content than (2), also held by the roots and rhizomes of *Phragmites*. The three shades of the diagram indicate the soil differences (see page 262).

The *Phragmites* forming this Plav was tall-stout. The aerial portion of the shoots shown is about 5·15 m. (about 17 feet) in length, measured from the surface of the Plav, and has a total length of about 6·8 m. (about 22 feet). The tallest shoots as a rule spring from the very base of the Plav. This is indicated in the diagram by the vertical line which continues the aerial portion downwards through the centre of the Plav-layer. The inflorescence (the flag of the diagram) measures about 45 cm.×15 cm. (18×6 inches). Water-roots as a rule hang from the base of the Plav-layer, as shown in the diagram; they are clean (light-coloured) if the Plav is floating in a considerable depth of water. Plate **15** is a photograph of a section cut through Nazaraou Rinok Plav.

SECTION II.

Phragmites (*P. communis β. flavescens*, Gren. & Godr.) and *Typha* Plav (*T. angustata*, Bory & Chaub.). This section was cut on September 20th, 1913, through the largest island of Lake Roșuleț. The thickness of the Plav is 1·6 m. (about 5 feet 3 inches), and its surface about 4 cm. (about 1½ inches) above that of the water. The depth to the sand, measured from the surface of the Plav, was about 2·9 m. (about 9 feet 6 inches) on Sept. 28th, 1913. This Plav consists of 3 layers; the three layers shown in the diagram do not, however, indicate soil differences, but the different living *plant*-layers which build up the Plav. Only 2 *soil*-layers could be distinguished, as is indicated by the two shades of the diagrams. (1) The top layer is black soil with *Polystichum Thelypteris*, Roth, rooted in it, and measures about 8 cm. (about 3 inches) in thickness. (2) The next layer consists of living and dead *Typha* rhizomes and remains with a few living *Phragmites* rhizomes interspersed; it is about 45 cm. (18 inches) in thickness, and the soil is dark. (3) This layer consists of living and dead *Phragmites* rhizomes, and is about 1·1 m. (about 3 feet 8 inches) in thickness. The dark-coloured soil is similar in appearance to that of layer (2). This Plav, according to measurements, was nearly aground on Sept. 6th—that is, of course, if the fluvio-lacustrine ooze overlying the basal sand-bed was of the same thickness on Sept. 6th and 28th. The ooze-layer is so loose in texture that it is constantly shifting.

The *Phragmites* here was also giant, but its taller shoots were only about 4·5 m. (about 15 feet) in length, as measured from the surface of the Plav. The exact depth from which these shoots arose was not ascertained, hence the dashes in the diagram terminating in the vertical line; however, in all probability they arose from the very base of the layer. The aerial portions of *Typha* measure about 2·3 m. (about 7 feet 6 inches), and

the *Polystichum* fronds about 1·2 m. (about 4 feet). A little *Hypnum* and *Epipactus palustris*, Crantz, were present. The mollusc *Dreissena polymorpha*, Pall., was attached to the reed-rhizomes forming the edge of the island.

Section III.

"Fixed Plav" of *Phragmites communis* var. *β. flavescens*, Gren. & Godr. (see page 259). The section was made on Sept. 19th, 1913, at the edge of the grind of Roşuleţ. The depth of water covering this "fixed Plav" was about 0·75 m. (about 2 feet 6 inches) on Sept. 28th. The thickness of the Plav is about 1·35 m. (about 4 feet 6 inches). This Plav is quite uniform in structure; it consists of densely packed reed-rhizomes, and the soil throughout is a fine and only slightly organic ooze (shown by the single light shade of the diagram). The depth of the sand, measured from the *surface of the water*, on Sept. 28th, was about 2·1 m. (about 7 feet).

The reed here was "*shitka*" or slender, and measured about 2·2 m. (about 7 feet 3 inches), from the surface of the Plav, and the inflorescence measures about 15 cm. × 8 cm. (6 × 3 inches). The accompanying plants are a few aquatics, i. e. *Nymphæa alba*, Linn., *Sium lancifolium*, Bieb., *Sium latifolium*, Linn., *Lemna trisulca*, Linn., and *L. minor*, Linn., *Stratiotes Aloides*, Linn., and *Hydrocharis Morsus-ranæ*, Linn.

Section IV.

Reed-Fen (*Phragmites communis*, Trin.). Section made on April 23rd, 1914, in the vicinity of Sutton Broad Laboratory on the River Ant, Norfolk. The top, or contemporary, fen-layer is about 1 m. (about 3 feet 3 inches) in thickness. The depth to the sand is about 5·2 m. (about 17 feet). The fen-layer consists of two layers: the top one, about 0·55 m. (about 1 foot 10 inches) in thickness, is almost exclusively living reed-rhizome and branched roots, and the lower layer mostly dead rhizomes and long mud-roots. The soil throughout the section is similar to the eye with the exception of the top soil, which is a little darker. The organic content of this fluvio-lacustrine ooze was estimated for me at Rothamsted. The loss on ignition (organic matter) was 41·76 per cent. A similar ooze covers the bottom of Barton Broad near the Herons' Carr; its loss on ignition was 40·23 per cent. The depth from the surface of the fen to the basal sand-bed (often coarse sand with a few flints) is in general far greater than in the delta. The greatest depth to the "hards" so far reached in the Broads was 31 feet (9·44 m.) in Salhouse Broad on July 27th, 1912*. In the delta, even at high water, I have only in a few places reached 3 m. (10 feet).

The length of the reed from the surface of the fen is about 1·8 m. (6 feet). The inflorescence measures about 25 × 12 cm. (about 10 × 5 inches).

Plate 25.

Dr. Antipa's Map of the Delta of the Danube.

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* The boring tool used on that occasion was designed by Mr. Horace Darwin, F.R.S., of the Cambridge Scientific Instrument Company, in conjunction with Mr. C. Lack.

On a Collection of Bornean Mosses made by the Rev. C. H. Binstead.

By H. N. Dixon, M.A., F.L.S.

(Plates 26, 27.)

[Read 6th May, 1915.]

A considerable number of collectors have brought back mosses from Borneo, from the early days of Korthals, Teysmann, and Motley onwards, but there has been very little published on the bryology of the island as a whole. Most of the records of these collections have been intercalated among those from other localities: *e.g.*, in Mitten's 'Samoan Mosses,' Dozy and Molkenboer's 'Musci Inediti Archip. Indici,' and the 'Bryologia Javanica'; the only papers of any importance of which I am aware dealing exclusively with the mosses of Borneo being Hampe's description of the mosses collected there by Beccari (1872), and the five pages devoted to the Muscineæ, by Mitten and Wright, of our own Transactions, in Dr. Stapf's "Flora of Mt. Kinabalu."

It is most desirable that the scattered records should be brought together, and some attempt made at a Prodromus of the Moss-flora of this large and botanically important island, and I had at first thought of incorporating my account of Mr. Binstead's mosses in an attempt to carry this out. I learnt, however, from Herr Max Fleischer—whose "Musci der Flora von Buitenzorg" has done much to form a preliminary basis for such a work—that he had abundant material at the present time from various collectors in Borneo, only partially worked out. Any thought on my part, therefore, of carrying out such a scheme would seem peculiarly inopportune at the present time. I have, therefore, practically confined myself to describing the collection of mosses made by the Rev. C. H. Binstead during a stay of a month or more in British North Borneo during April-May, 1913, part in a limited area on the coastal region of the north-eastern projection of the island, and part about Tenom, some few miles from the west coast, reached by rail from Jesselton.

The former collection brought out in a very interesting way the peculiar ecological distribution of the remarkable and striking genera *Syrrhopodon* and *Calymperes*. These two genera, numbering between them at least 450 species, are found in every quarter of the tropical and sub-tropical world, a single species being stranded in Europe, on the Mediterranean island of Pantellaria; but they are almost exclusively confined to the insular and littoral districts of these regions. A very large proportion, probably 50 per cent., are entirely insular, while of those with a continental distribution only a

minute percentage are found at any great distance from the sea. A species of the Calymperaceæ of unknown origin might be predicated as of coastal origin with at least as much certainty as a volcano. They are not, however, by any means maritime plants in the sense in which the term is ordinarily used; nor are they in any marked degree hygrophytic, being usually found on the bark of living or more frequently rotting tree-trunks. Out of 140 packets sent by Mr. Binstead from the N.E. coastal region, no less than 50 belonged either to *Syrrhopodon* or to *Calymperes*, a fact which clearly marks the firm footing which these genera have in the bryological vegetation of that region; nor is the large proportion due to any great conspicuousness on the part of the plants, which as a rule are not of a very striking habit, and are almost always sterile, or were at least in the specimens of Mr. Binstead's collecting.

Moreover, of thirty species of the two genera five were undescribed. Out of about 220 known species of *Calymperes* some twenty are found in Borneo, five (including the new species described here) being endemic; while of 230 species of *Syrrhopodon*, twenty-five occur, five of these also being endemic.

Apart from these genera the collection contained several novelties, as well as a good many species now for the first time recorded from the island, and emphasizing the relationship of the bryological flora with the Indo-Malayan on the one hand, and the New Guinea and Oceanic on the other.

Mr. Binstead's collecting was all done at low elevations, mostly at practically sea-level, and under very difficult and unfavourable bryological conditions. The mosses of the dense jungle are for the most part confined to the *upper parts* of the trees, where they receive a certain amount of light and grow among epiphytic orchids. They are therefore inaccessible except where trees have been felled, and some of these, which promised—at a slight distance—a good hunting-ground, were equally inaccessible owing to the impenetrability of the jungle, to great obstacles formed by the charred remains of gigantic trunks felled long ago, together with the intense moist heat. It is much to be regretted from a bryological point of view that botanists who have collected on Mt. Kinabalu have for the most part contented themselves with describing the "zones of moss and fog," the tree-trunks "inches deep in moss," and so on, of the upper slopes of that mountain, while the number of species that have been actually collected is comparatively small. Sufficient material, however, has been studied to indicate an almost entirely different moss-flora from that which obtains in the lower levels. Thus among the thirty-one species of moss recorded in the Flora of Mt. Kinabalu (Trans. Linn. Soc. Ser. 2, Bot. vol. iv. 1894, pt. 2), by Mitten and Wright, most of them collected at 5000 feet and upwards, only four are found in the 125 or so species listed below.

I have included in this paper a certain number of records of mosses

gathered by Mr. V. St. John Down, and by Mr. J. H. Cranston, collected and sent me at an earlier date by Mr. Binstead, as well as a few collected some years back by Rev. Chas. Hose (Bishop Hose), which I received from Mr. W. R. Sherrin. A few of Mr. Binstead's collection were made for him by Mr. E. O. Rutter, D.O., at Rundum, near Tenom.

My thanks are due to the authorities at Kew and the British Museum for assistance in this paper, as well as to Monsieur Thériot and Herr Max Fleischer for much valued help.

DICRANACEÆ.

Wilsoniella tonkinensis, Besch. Sandy bank in open place near Sandakan, c.fr. (No. 7); stony bank, Tenom, c.fr. (No. 141). The latter a lax, long-leaved form, strongly recalling *Trematodon*.

I find nothing to separate the Bornean plant from the Tonkin species. The few species of the sub-genus *Eu-Wilsoniella* of this peculiar and interesting genus are closely allied to one another, and are probably, as hinted by Bescherelle, all racial forms of one or two species. The inflorescence, as pointed out by Bescherelle (Flor. Bryol. de Tahiti), affords the most distinct character; in *W. Karsteniana*, C. Muell., from Australia, and *W. pellucida* (Wils.) from Ceylon and Java, the ♂ flower is single or on a short branch below the perichætium; in *W. Jardini* (Schimp.) from Tahiti and Samoa, the plant is still autoicous, but the ♂ branch is ramified, with a terminal flower on each division; the dioicous *W. tonkinensis* is described by Bescherelle (*op. cit.*) as having *the ♂ stems simple or fasciculate at the base, with extremely narrow leaves and numerous flowers.* This somewhat unusual form of the male plant I found actually to occur in Mr. Binstead's specimens from Sandakan; the ♂ stems are frequently simple, but more often are ramulose, emitting clusters of two or three ramuli at different points of the stem, each terminating in a ♂ flower; not at all unlike the figures of the ♂ plant of *Dicranella cerviculata*, Bry. Eur. tab. 56. I have figured one of these male plants on Pl. **26.** fig. 1.

In order to verify the identity of the Bornean plant with *W. tonkinensis*, I examined the type of Bescherelle's species at the British Museum, where to my surprise I found that the supposed ♂ flowers of Bescherelle did not belong to the *Wilsoniella* at all, but to a *Dicranella*, a fertile plant of which occurs mixed up with the rest of the material! That it was actually this *Dicranella* which Bescherelle examined admits of no dispute, as he has carefully separated out the ♂ plants which he had dissected and placed them in a separate envelope. This at once explains the "extremely narrow leaves" which he attributes to the male plant. The remainder of the gathering from Tonkin exhibits no ♂ flowers, and it is truly dioicous, and in other respects agrees exactly with the Borneo plant. It is a curious fact that Bescherelle

should have accidentally almost exactly described the somewhat unusual ♂ inflorescence of *Wilsoniella tonkinensis* without, as a matter of fact, having ever seen it!

Roth (die Aussereuropäisch. Laubmoose, i. 323) has been misled by the same circumstance; the ♂ plants furnished him from the Paris Museum were evidently those of the *Dicranella* (cf. *op. cit.* tab. xxxii. 6); in fact, he has noted of the species "Sie erinnert in mancher Beziehung an eine *Dicranella*," and the bulk of the description, with all the figures, applies to the *Dicranella* alone.

I may also, while referring to Roth's treatment of *Wilsoniella*, call attention to the fact that in the Key to the Species *W. Hampeana* (C. M.) is classed among the autoicous species, as it was indeed described by C. Mueller; Salmon, however (Journ. Bot. 1902, p. 274), who examined the type material, states that it is actually dioicous.

Microdus Miquelianus (Mont.), Besch. (*Weisia Miqueliana*, Mont.). Sandy banks, Sandakan, c.fr. (Nos. 3, 4, 5, 6, 34); stony banks in jungle, Sapong, near Tenom, c.fr. (Nos. 142, 143); shaded sandy, stony bank near Tenom, c.fr. (No. 139).

Var. rigescens (Broth.), Fleisch. Railway-bank near Tenom, c.fr. (No. 140). This plant (*Wilsoniella rigescens*, Broth.) is very distinct in appearance, but Fleischer is no doubt right in subordinating it as a var. to *M. Miquelianus*, with which it agrees in structure.

Microdus macromorphus, Fleisch. Wet rock, Sandakan, c.fr. (No. 40). I have not seen authentic specimens of Fleischer's species, but from the description and figures I have no hesitation in referring this plant there. It is a tall plant with stems fully an inch long and laxly foliate, the seta longer, stouter, and of a deep red throughout; the whole plant in general more robust, but not separated by any very definite structural characters from the preceding species. It is a new record for Borneo.

? Campylopus comosus (Hornsch. & Reinw.), Bry. jav. Sandakan (No. 8). I cannot separate this in any way from the Indo-Malayan plant. Fleischer describes *C. comosus* as a "Hochgebirgsmoos," but if I am correct in referring to it certain plants from Ceylon and Singapore, it is not exclusively confined to high altitudes. It is possible, however, that some confusion exists between this and *C. ericoides* (Griff), which appears to be very near to *C. comosus*.

? C. calodictyon, Broth. Rundum, ♀ (No. 213), leg. E. O. Rutter, D.O. Fleischer writes that this is probably Brotherus' species, though in absence of fruit it cannot be definitely determined.

LEUCOBRYACEÆ.

LEUCOBRYUM SANCTUM (Brid.), Hampe. Rock in jungle, Sandakan (No. 11); Rundum, leg. E. O. Rutter (No. 217); Sadong, Sarawak, leg. J. H. Cranston, 1900 (No. 61); Baram (from inside of a monkey-skin at Brit. Mus.), leg. Rev. Chas. Hose (No. 103).

L. glaucissimum, C. Muell., sp. nov., MS., 1898, Ins. Borneo occid., Lohabar, distr. Pontianak, ad rad. montium, leg. J. B. Ledru, July 1897, det. C. Müller, herb. Levier, is I think without any doubt *L. sanctum*. It appears to be the same thing as *L. sanctum* f. *glaucissimum*, Fleisch., issued by Max Fleischer as No. 451, Musc. Frond. Arch. Ind. et Polynes., Borneo, 1898–9, leg. Nieuwenhuis.

L. JAVENSE (Brid.), Mitt. Rundum, leg. E. O. Rutter (Nos. 223, 224, 225); Baram (from inside of a monkey-skin at Brit. Mus.), leg. Rev. Chas. Hose (No. 102).

L. ADUNCUM, Doz. & Molk. Rundum, leg. E. O. Rutter (No. 219); shaded stony bank, Sandakan (No. 10); this latter is a very pretty form, of a bright pale green colour, the stems readily falling apart, not matted together as usual in *L. aduncum*, and with secund but very little falcate leaves.

L. SCALARE, C. Muell. Rundum, leg. E. O. Rutter (Nos. 214, 215, 216, 220, 222). Fleischer determined No. 216 as f. *brachyphylla*, Fleisch., and some of the other numbers might perhaps be referred to the same form, but the line between it and the type is not easy to draw.

L. aduncum and *L. scalare* have a very similar distribution, and are not very widely apart as species; still they have a more or less distinct habit, and I am quite unable to understand why the Andaman Is. plant collected by Man and distributed by Levier should have been sent out under the name of *L. aduncum* (with the authority apparently of both C. Mueller and Brotherus); I do not think there can be the least doubt that they belong to *L. scalare*.

L. CHLOROPHYLLOSUM, C. Muell., f. MINOR, Fleisch. Rundum, leg. E. O. Rutter (Nos. 218, 221); det. Fleischer.

LEUCOPHANES CANDIDUM (Hornsch.), Lindb. Decayed wood in shade. Sekong (Nos. 66, 68); Sadong, Sarawak, 1900, leg. J. H. Cranston (No. 58).

L. ALBESCENS, C. Muell. Decayed wood in shade, Sekong (Nos. 70, 73, 80). Between this plant and some others, e. g. *L. glauculum*, C. Muell., there has been much confusion. It may be worth while to refer to some of the correspondence I have had upon the above plants. Monsieur Cardot, to

whom the above plant (No. 80) was submitted, wrote: "Votre *Leucophanes* est bien identique à un échantillon que je possède, de l'île Célèbes, étiqueté *L. albescens*, C. M., et provenant de l'herbier Lacoste. C'est sur un échantillon du même provenance que Fleischer a établi sa description du *L. albescens*, laquelle s'applique très bien à votre plante. Mais je ne connais pas le type du *L. albescens* de Paulo-Penang, et la description de Müller ne parait guère convenir ni à la plante de Célèbes, ni à votre plante de Bornéo. D'autre part, Brotherus a distribué sous le nom de *L. albescens* une mousse des Philippines qui me parait bien distincte spécifiquement de celle de Célèbes et de Borneo; peut-être est-ce le véritable *L. albescens* de Müller. Il faudrait voir le type de ce dernier pour pouvoir élucider la question."

It appeared worth while to go more closely into the problem involved, and I asked Herr Fleischer, who was at the time in Berlin, if he could examine the types and inform us which of the plants in question was the true *L. albescens*, C. M. Herr Fleischer was good enough to do so, and wrote: "Ihr Exemplar No. 73 ist *Leucophanes albescens* C. M., und mit den Originalen von C. Müll. aus *Pinang conform.* Die Art is ziemlich veränderlich besonders was die Länge der Blätter anbelangt, die oft zu bedeutend *kürzeren* Blättern variiren. So befinden sich im Herb. C. Müll. selbst 4 Exemplare aus (1) Pinang mit längeren Blättern, (2) Borneo (Lacoste), etwas kürzeren Bl., (3) & (4) von den Nicobaren & Anambas Eilanden mit [den kürtesten Blätter]. Auch das Stereom ist dorsal mehr oder weniger gezähnt bis fast glatt. Beiliegend ein von mir vor circa 14 Jahren bestimmtes Exemplar aus Singapore. Das Exemplar von den Philippinen, ex herb. Cardot, des Brotherus, gehört aber nicht zu *L. albescens* sondern zu *L. glaucum* C. Müll.; ebenso wenig mein Exemplar in M. Archip. Ind. No. 406."

The three numbers cited above may therefore certainly be taken to be the true *L. albescens*, C. M. Two other gatherings of Mr. Binstead's appear to be somewhat distinct, in the rather more robust habit, and in having the leaves more conspicuously spiculose along the dorsal median stereom, as well as more strongly toothed at the upper margin; moreover, more chlorophyllose below, and therefore showing the hyaline border more distinctly. I do not know how far these characters are constant, and am inclined indeed to be very dubious, but in so far as they go the plants agree very well with

LEUCOPHANES SUBGLAUCESCENS, C. Muell. (ined.). Timorlaut, 1891, leg. Micholitz, No. 8, herb. Brotherus in Herb. Kew. These plants were from a tree, Sandakan (No. 24); decayed log in shade, Sekong (No. 74). They are strongly spiculose at the back, more so in fact than in Micholitz's plant. Several of the species of this group are extremely close to one another, and a revision of the genus would probably lead to a considerable reduction, and is, as Cardot writes, highly desirable. The degree of spiculosity of the dorsal stereom is, for one thing, certainly a very unreliable character.

LEUCOPHANES OCTOBLEPHAROIDES, Brid. Decayed tree-stumps in old rubber plantation, near Sandakan (No. 49 *a*); rotting log in jungle, Sapong, near Tenom (Nos. 144, 145).

OCTOBLEPHARUM ALBIDUM (Linn.), Hedw. Rotting stump, near Sandakan, c.fr. (No. 13); decayed log in shade, Sekong, c.fr. (No. 69).

ARTHROCORMUS SCHIMPERI, Doz. & Molk. Tree in jungle, Sandakan (No. 14), decayed log in shade, Sekong (Nos. 67, 71, 72); Sadong, Sarawak, leg. J. H. Cranston, 1900 (Nos. 83, 92).

EXODICTYON BLUMII (Bry. jav.) Fleisch. Sibetic Is. (No. 120).

FISSIDENTACEÆ.

FISSIDENS ZOLLINGERI, Mont. Decayed tree-trunk in old rubber plantation, Sandakan, c.fr. (No. 49 *c*); sandy bank in shade, Tenom, c.fr. (No. 147). These agree quite well with the Javan plant, which has not been previously recorded from Borneo.

FISSIDENS (Semilimbidium) AUTOICUS, Thériot & Dixon, sp. nov. (Pl. **26**. fig. 2.)

Autoicus; flores masc. *numerosi in axillis caulis fertilis foliorum* siti. Sat robustus, saturate viridis; caulis 1–1·5 cm. altus, simplex vel parce ramosus. Folia 10–20-*juga*, *fragilia*, sicca falcata haud crispata, 1 mm. longa, *late oblonga*, *brevissime acuta*, lamina dorsali ad folii insertionem subabrupte desinente, lamina vera circa dimidiam folii longitudinem æquante, apice media parte inter costam et marginem (nec apud marginem) desinente; lamina vera plus minusve distincte (sæpe obsolete) limbata, cetera omnino elimbata, *integra vel minutissime crenulata*. Costa sat valida, subpellucida, percurrens. Cellulæ *sat magnæ*, 8–12 μ latæ, irregulariter hexagonæ, leptodermicæ, chlorophyllosæ, *sat pellucidæ*, læves. Fructus terminalis; bracteæ perichætii foliis subsimiles; seta pro magnitudine plantarum brevis, 2–3 mm. longa, gracilis, flexuosa. Theca parva, erecta vel suberecta, angusta, *collo longo defluente*, operculo longe acute rostrato.

Hab. Wet sandstone rock, Sandakan, 2 Apr. 1913 (No. 18).

A well marked species, among the taller of the § *Semilimbidium*, distinct in the axillary ♂ inflorescence, the broad leaves scarcely narrowed to the apex, the distinct somewhat large cells, the slender seta and long-necked capsule.

F. CEYLONENSIS, Doz. & Molk. Sandy bank, Sandakan (No. 17); earthy bank, Kudat, c.fr. immatur. (No. 148).

F. CRASSINERVIS, Lac. Stony bank, Sandakan, c.fr. (No. 15); shaded sandstone rock in jungle stream, Sandakan, c.fr. (No. 16); jungle, Sibetic Is., c.fr. (Nos. 121, 126). No. 126 has the cells slightly larger than usual (12–18 μ), and the nerve generally excurrent.

FISSIDENS ZIPPELIANUS, Doz. & Molk., var. FONTANUS, Fleisch. Boulder in stream, Sapong, near Tenom (No. 150); det. Fleischer.

F. NOBILIS, Griff. Shaded boulder in jungle cascade, Tenom (No. 149). So far as I am aware, this fine species has not been recorded before from Borneo. *Distrib.* North India (Himalayas, Assam), Ceylon, Java, Sumatra, Hongkong.

CALYMPERACEÆ.

SYRRHOPODON BORNENSIS (Hampe), Jaeg. Decayed log in shade, Sekong (No. 87).

S. REVOLUTUS, Doz. & Molk. Decayed log in shade, Sekong, mostly c.fr. (Nos. 80 *a*, 81, 88, 89, 92). No. 80 *a* is a form with the leaves subobtuse and subcucullate; No. 81 a tall form with a seta considerably over 1 cm. long. On palm-stem, Sandakan (No. 9).

S. CONFERTUS, Lac. Sadong, Sarawak, 1901, leg. J. H. Cranston (Nos. 90, 95), No. 90 c.fr.

S. ALBO-VAGINATUS, Schwaegr. Decayed wood and trees, Sandakan (Nos. 22, 23); Sekong, c.fr. (Nos. 82, 83, 90); Sibetic Is. (No. 123); Sapong, near Tenom (No. 159); Sadong, Sarawak, 1900, leg. J. H. Cranston (Nos. 81, 89).

S. SPICULOSUS, Hook. & Grev. Sandakan, c.fr. (Nos. 12, 19); Rundum, leg. E. O. Rutter (No. 153).

S. TRACHYPHYLLUS, Mont. Rotting wood, Sandakan (No. 34). Mr. Binstead's plant agrees in everything with specimens of Montagne's at Kew, except that the nerve is more spiculose at the back, for some distance down.

I have examined the original of *S. gracilis*, Mitt. (Tristan d'Acunha, leg. Milne) at Kew, and find it to be certainly identical with *S. trachyphyllus*. The back of the nerve is not smooth, as stated, but variously spiculose-hispid near the extreme tip, though *some* leaves have the nerve actually smooth throughout. In fact, precisely the same degree of variation obtains as in Montagne's Singapore *S. trachyphyllus* in Herb. Kew.

*S. TRACHYPHYLLUS subsp. ALBIFRONS, Thér. & Dixon, subsp. nov.

Stirps pergracilis, *albus*; folia longiora, *angustiora*, e basi pro more breviore vaginante *elongata, angustissime linearia, subtubulosa*; costa æque ac limbus marginalis perhyalina, siccitate nitens. Seta 3–4 mm. longa, gracillima.

Hab. Jungle, Sandakan, 4 Apr. 1913, c.fr. (No. 30).

Structurally this plant is nearly related to *S. trachyphyllus*, but the white colour, the narrower leaves, subtubulose above even after moistening, with the lamina considerably longer in proportion to the base, give it a very

marked character. In *S. trachyphyllus* the lamina is approximately equal to the base, or but little longer; in *S. albifrons* it is from 1½ to 3 times the length of the base.

SYRRHOPODON (Eu-syrrhopodon § Cavifolii) LEDRUANUS, C. Muell., MS. in litt. ad E. Levier. (Pl. 26. fig. 3.)

Planta robustiuscula, subrigida, pallide vel intense viridis; caulis circa 2 cm. altus. Folia e basi vaginante adpressa *erecto-patentia substricta, sicca parum mutata, leniter rigide curvata*, 3–4 mm. longa, e basi anguste oblonga raptim in laminam peranguste linearem *planam circa duplo longiorem* contracta, apice obtuso grosse eroso-dentato; lamina ad marginem *per ⅔ longitudinem angustissime hyalino-limbata*, integerrima, apicem versus dense serrulata; cellulæ ovales subrotundæ, obscuræ, 5–7 μ latæ, dorso præcipue ad marginem *grosse alte papillosæ*; costa infra apicem desinens, dorso *spiculis dense confertis scaberrima.* Folii basis cellulis perangustis seriebus pluribus flavidis marginata, superne 2–6 *spiculis utrinque ciliata.* Cancellina e cellulis hyalinis laxiusculis *elongate* rectangularibus instructa. Bracteæ perichætiales a foliis vix diversæ. Seta 1 cm., rubra; theca parva, subcylindrica, erecta, calyptra apice scaberula, operculo subulato-rostrato recto, peristomii dentibus late lanceolatis grosse tuberculatis.

Hab. Distr. Pontianak, Ins. Borneo, 1897, Ledru: det. C. Mueller, Nos. 2337, 2335.

Nearly allied to *S. mammillosus*, C. Muell., but that has the leaves distinctly patent, the cells without the high spiculose papillæ, and the border of the leaf-base pectinate with numerous long closely-set cilia. Here the cilia are extremely few in number, often reduced to two or three, and sometimes almost obsolete. It is a much larger, more robust plant with longer leaves than *S. spiculosus* and *S. trachyphyllus.*

Nov. var. INVOLUTUS, Thér. & Dixon. Folii lamina ad apicem *marginibus incurvis concava.*

Hab. On coconut palm, Tawao, leg. Binstead, 16 Apr. 1913 (No. 135).

The character italicized is marked, but does not seem of sufficient importance to warrant a higher than varietal distinction.

SYRRHOPODON (Eu-syrrhopodon § Tristichi) PATULIFOLIUS, Thér. & Dixon, sp. nov. (Pl. 26. fig. 4.)

Habitu *S. tristichi* Nees sed paullo gracilior. Cæspites densi, superne pallidi infra fusci; caulis simplex vel subsimplex, *circa 4 cm. altus*, gracilis, *strictus*, a foliorum distantium vaginis albidis nitescens. Folia *subtristicha, remotiuscula*, e basi vaginante brevi *abrupte* (sicca madidaque) *patula* vel siccitate recurva, 5–7 mm. longa, lamina peranguste lineali marginibus supra incurvis acuta cellula apicali spiculiformi mucronata; limbo hyalino, areolatione costaque eis *S. Ledruani* subsimilibus, sed cancellinæ cellulis ubique

breviter rectangularibus ; limbo partis folii vaginantis superne *spiculis vel ciliis nonnullis remotiusculis* armato. Seta 1 cm. longa ; theca parva, sicca vacua subcylindrica, rufo-fusca.

Hab. Sandy bank about roots of trees in jungle, Sandakan, 31 Mar. 1913, c.fr. (No. 26).

In spite of the somewhat ciliated shoulder of the leaf-base, I think this distinct species must be placed in the § Tristichi rather than the Cavifolii, the habit and leaf-arrangement being very nearly that of *S. tristichus*, from which as from its allies our species differs evidently in the armature of the leaves, while from *S. Ledruanus*, *S. spiculosus*, etc., it differs at once in the robust habit and distant, widely spreading subtristichous leaves. *S. mammillosus*, C. Muell., resembles it somewhat in habit, but has the leaf-base densely pectinate with long closely-set cilia.

SYRRHOPODON CILIATUS (Hook.), Schwaegr. Sandakan (No. 25) ; Sekong (Nos. 85, 94) ; Sadong, Sarawak, 1900, leg. J. H. Cranston (Nos. 89, 97). These all belong to the f. *pseudopodianus* of Fleischer ; but Mr. Binstead's No. 94 shows both fruit and pseudopodia growing closely associated on the same tuft, if not actually on the same plant.

S. (Thyridium) REPENS, Harv. Tree, Sandakan (No. 33) ; Sadong, Sarawak, 1901, leg. J. H. Cranston (No. 111).

S. (Thyridium) MANII, C. Muell. Tree in jungle, Sandakan (No. 41).

Fleischer has pointed out the near relationship of these two species to one another. He distinguishes them as follows :—

S. repens.	*S. Manii.*
Hyaline border reaching apex.	Hyaline border ceasing at $\frac{2}{3}$ leaf.
Margin denticulate, almost ciliate.	Margin slightly toothed.
Cells incrassate, usually transversely oval.	Cells less incrassate, rarely transversely oval, irregularly rounded.

The plant from Sadong above has the border highly toothed, the cells usually transversely oval ; Mr. Binstead's No. 41 has the margin scarcely toothed, the cells not transversely oval, the leaves much more opaque ; No. 33 is somewhat intermediate in characters between the two. In none of them does the border reach the apex. I am strongly of opinion that it is impossible to draw any clear line of distinction between the two species.

S. (Thyridium) FASCICULATUS, Hook. & Grev. Jungle, Sandakan (No. 48) ; Sadong, Sarawak, 1901, leg. J. H. Cranston (No. 50).

S. (Thyridium) UNDULATUS (Doz. & Molk.), Lindb. Sandakan (No. 38) ; decayed log in shade, Sekong (Nos. 91, 93) ; Rundum (No. 226).

Syrrhopodon (Thyridium) Jungquilianus, Mitt.* Sibetic Is. (No. 122).

Fleischer (Musci .... von Buitenzorg, i. 232) remarks that *Thyridium undulatum*, *T. Junquillian*, *T. adpressum*, *T. papuanum*, appear to be subspecies of a polymorphic type. To these I should be inclined to add *T. fasciculatum*. Fleischer relies on the robust habit to distinguish *fasciculatus* from *undulatus*, together with the nerve slightly excurrent in the rather broadly acute point, the hyaline border usually extending to the somewhat toothed apex, the nerve rough at the back above, the hyaline cells of the cancellina scarcely reaching higher at the nerve, so that the line separating it from the lamina cells is almost straight and horizontal.

S. undulatus he describes as much more slender, with the nerve ceasing below the gradually narrowed, more acute point, the hyaline border nearly always ceasing some way below the subentire apex, the nerve smooth at back, and the cancellina cells reaching higher near the nerve, so that the line of delimitation is curved or arched.

I have examined numerous specimens of each in order to verify these distinctions, with no very satisfactory results. Thus *S. codonoblepharum*, C. M. (in herb. Mus. Brit.), Padang, Sumatra, Hb. Lugd. Batav., has nearly all the characters of *S. undulatus*, but the border reaches the apex. *S. codonoblepharum*, planta javanica a cl. Zollingero lecta, Hb. Shuttleworth (in herb. Mus. Brit.), is almost exactly similar. Mr. Binstead's No. 48, which I have referred above to *S. fasciculatus*, is a very robust, purplish-black form with pale tips, agreeing with *S. fasciculatus* as above described in every particular, except that the cancellina cells are very distinctly and very constantly higher towards the nerve. No. 91 is true *undulatus* in all structural points, but is very robust. No. 226 has the nerve smooth, the cancellina slightly higher at nerve, the apex of the leaf somewhat intermediate in form, apiculate with the nerve-point, the border generally reaching nearly to the apex, the habit rather robust—on the whole an indeterminate plant.

I incline to think that the size of the plant, and extension of the hyaline border towards the apex are not characters to be relied upon ; that the wider point, stouter, rough, subexcurrent nerve, and especially the straight, horizontal upper delimitation of the cancellina, are the best characters of *fasciculatus*, the more acute point, narrower, smooth nerve, and arched cancellina line characterizing *undulatus*; but these cannot be considered absolutely constant.

S. Jungquilianus, Mitt. is more distinct from the above than they are from one another. In both the species already referred to the lamina is (when moist) bent back somewhat markedly from the erect, much broader base. In *S. Jungquilianus* the much smaller leaves are nearly straight and suberect,

* This peculiar name is with very little doubt due to a misreading of Mitten's MS. by the authors of the Bry. jav. Mitten, it may be presumed, intended *Junghuhnianus*. In the Bry. jav. it appears as *Junquilian*. Fleischer cites it as *Junquillian*. I have preferred to give it as written by Mitten himself in Journ. Linn. Soc. (Bot.) x. 188, viz. *Jungquilianum*.

the base very little and not abruptly widened, the hyaline border (at shoulder particularly) considerably narrower; in other leaf characters resembling *S. undulatus*; it is a much more slender plant than either.

S. undulatus, Lindb., Celebes, Lacoste, in Herb. Hampe., and *S. undulatus*, Sambor, Borneo, 1903, leg. Micholitz, det. Brotherus No. 249, are certainly *S. Jungquilianus*. *Thyridium luteum*, Mitt. I suspect strongly to be the same thing.

SYRRHOPODON (Thyridium) FLAVUS, C. Muell., n.f. major. Sekong (No. 76). The only specimen of *S. flavus* that I have been able to consult ("*S. tenellus*, Doz. & Molk." in Herb. Schimp. at Kew) agrees with this in everything but its smaller size, and the hyaline border usually not reaching so high (in No. 76 it reaches nearly to the apex); in some leaves, however, it nearly attains the apex. Mr. Binstead's plant, I think, must be a robust form of this species; the hyaline border at the widest part is as much as 10 rows of cells in breadth; the genera habit is that of *S. Cardotii*, but the leaf-apex quite different.

S. (Thyridium) BINSTEADII, Thér. & Dixon, sp. nov. (Pl. **26**. fig. 5.)

Caulis repens, cæspites densos habitu *S. undulati* sed *multo minores* instruens, ramis circa 1–1·5 cm. altis. Folia erecto-patentia, siccitate falcato-incurva, sicca madidaque valde undulata, *brevia*, vix 1 mm. superantia, e basi amplexicauli cito in laminam oblongam angustata, *apice abrupte in cuspidem linearem longam proboscideam obtusam scaberulam sæpe apice gemmiparam* constricta. Limbus folii inferne *latus* (in parte superiore basis 8-seriatus vel supra) superne tenuiter denticulatus, infra apicem evanidus, e cellulis tamen laminæ marginalibus 1–2-seriebus pallidioribus echlorophyllosis ad apicem productus. Cellulæ chlorophyllosæ *perminutæ*, ovales, 3–5 μ latæ, perdensæ, minutissime papillosæ *obscuræ*. Cancellina superne *oblique angustata*, partem vaginantem folii *longe superans*, tamen propter 3–5 series cellularum juxtacostales nunc æquilongas nunc inæquales *ambitu valde irregulari*, e cellulis hyalinis pro more *angustis lineari-rectangularibus* ter-sexies longioribus quam latis instructa. Costa tenuiuscula, dorso lævis, cuspidem terminalem percurrens.

Cetera ignota.

Hab. Jungle, Sandakan, 4 Apr. 1913 (No. 28). With *S. undulatus*.

A distinct species when carefully examined, though very likely to be overlooked for *S. undulatus* or one of its allies. The leaf-outline is in some respects intermediate between *S. undulatus* and *S. Jungquilianus*, having the base less abruptly narrowed at the shoulder and the lamina less reflexed than in the former, but more conspicuously than in the latter. The narrow cancellina cells are a strong feature, as is also the peculiar form of the leaf-apex, and these, apart from other characters, at once distinguish it from *S. Cardotii* and all the allied species.

SYRRHOPODON MUELLERI (Doz. & Molk.), Lac. Sadong, Sarawak, 1900, leg. J. H. Cranston (No. 80).

Var. STRICTIFOLIUS (C. Muell.), Dixon, comb. nov.

Syn. *S. strictifolius*, C. Muell. in Geheeb, Neue Beitr. zur Moosfl. v. Neu Guinea, p. 3, 1889 (nec *S. strictifolius*, Mitt. in Fl. Vit. p. 388, 1871).
S. novo-guineënsis, Par. Ind. p. 1252.

Tree in jungle, Sandakan (Nos. 23 *a*, 27, 42).

I have compared this plant with a specimen of the New Guinea moss (German New Guinea, 1837, leg. Kaernbach, ex herb. Mus. Berolinens.), at Kew, and have no doubt they are the same thing, and I should also refer to it a plant of Micholitz's from New Guinea, determined by Brotherus as *S. Muelleri.* This latter shows very much variation in the leaf-point, sometimes broad and obtuse, at others subobtuse and cuspidate, and again finely drawn out and subulate, all in the limits of a single stem; the broader pointed leaves agreeing exactly with the *S. strictifolius*, leg. Kaernbach. Geheeb has drawn attention to the close resemblance between this and *S. Muelleri*, and I am convinced it can rank no higher than a variety of that species, a conclusion greatly fortified by its occurrence within the area of the typical plant. It scarcely differs except in the colour, usually green and not yellowish brown, and the straight, rigid leaves which retain their position and form when dry, instead of becoming slightly twisted and flexuose, as in the type of *S. Muelleri.*

S. strictifolius, Mitt. is a quite different thing.

S. CROCEUS, Mitt. Tree in jungle, Sandakan (Nos. 20, 21).

SYRRHOPODON (Orthotheca) TUBERCULOSUS, Thér. & Dixon, sp. nov. (Pl. **26**. fig. 6.)

Cæspites dense, *rigidi*, caulibus subsimplicibus 1–2 cm. altis, saturate virides, robustiusculi. Folia subpatentia, *stricta, siccitate parum mutata, rigida*, 4–5 mm. longa, e basi perangusta vaginante albidissima circa $\frac{1}{3}$ longitudinem totius folii æquante sensim in laminam loriformem strictam angustata. Costa basin versus validiuscula, superne *perrobusta*, $\frac{1}{3}$–$\frac{1}{2}$ laminæ latitudinem æquans, opaca, intense viridis, *dorso valde prominens, grosse tuberculosa*, superne in cuspidem steliformem robustam scaberrimam apice sæpe dilatatam scutiformem gemmiparam excurrens. Cancellinæ cellulæ juxtacostales *magni, brevissime rectangulares vel subquadratæ*, marginem versus sensim angustatæ; superne *altissime scalariformes, 1–2-seriebus partem folii basilarem longe superantibus.* Cellulæ laminæ parvæ, 5–7 μ, quadrato-rotundæ, perchlorophyllosæ, virides. Limbus folii in parte basali *distincte intramarginali*, e pluribus seriebus cellularum angustissimarum chlorophyllosarum formatus, validus, bene notatus, supra basin *limbum intramarginalem angustam antea subalatam* instruens, inde *toto margine valde*

incrassato, tuberculis magnis, seriebus transverse positis dense grosse corrugato-scabro.

Cetera ignota.

Hab. Jungle, Sekong, 22 Apr. 1913 (No. 84).

A very marked and curious species, quite distinct in its leaf-structure from any others of the Oriental species of the genus known to me. The habit is somewhat that of *S. strictus*, Mitt. from Ceylon, but the structure is quite different. It is also separated from all the allied plants in having the inner rows of cancellina-cells reaching far above the leaf-base. The structure of the leaf-border is very peculiar; it is thickened, to the width of several rows of cells, and is furnished, both back and front, with densely, regularly placed transverse rows of nodules, which are not simply papillose thickenings of the cell-walls, but are rather of the nature of tubercle-shaped cells, themselves often somewhat papillose on the surface. This gives the margin a closely pectinate-serrate appearance; the tubercles on the back of the nerve are similar, but in this case are smooth.

Calymperes Hampei, Bry. jav. Coconut palm, Sandakan (No. 29 b). The Bornean plant is separated by Bescherelle as *C. Sandeanum*, but Fleischer unites the two, no doubt rightly. Mr. Binstead's plant, in fact, inclines to *C. Hampei* rather than to *C. Sandeanum*, in so far as the form of the cancellina gives any distinction.

C. Fordii, Besch. in Ann. sc. nat., Bot. 8me sér. i. (1895) p. 284.

Syn. *C. Thwaitesii*, Besch. op. cit. p. 306.

Rotting wood near Tenom (No. 152).

Fleischer has remarked on the close relationship of *C. Fordii* and *C. Thwaitesii*, considering *C. Fordii* as only a subspecies of the latter. I think it is necessary to go further and unite the two. The character of the inner cancellina-margin, having the juxta-costal rows shorter than the median ones, while in *C. Thwaitesii* they are longer, cannot be held to have much weight in these species any more than in the group of *C. Hampei*; moreover, the type of Bescherelle's *C. Fordii* (Hongkong, leg. Ford) does not show by any means a uniformity in this respect. Nor does the geographical distribution lend itself to their segregation from one another, for if *C. Thwaitesii* be maintained, Mr. Binstead's No. 152 must certainly be referred to it rather than to *C. Fordii*, having a much more robust habit, with the cancellina of *C. Thwaitesii*; while I have a South Indian plant which must certainly be placed under *C. Fordii* rather than *C. Thwaitesii*! The number of rows of marginal cells, exterior to the teniole at the shoulder, is no doubt greater in the Ceylon plant (*C. Thwaitesii*), but it varies appreciably even in Bescherelle's type, and is certainly not correlated with the other characters attributed to that species. A plant of Mr. Binstead's from

Peradeniya Gardens, Ceylon, for example, has the cancellina outline of *C. Thwaitesii*, but in size and other characters is nearer *C. Fordii*.

If the two are united I suppose that the name *C. Fordii*, as the earlier, must stand.

Calymperes tenerum, C. Muell. Coconut palm, Sandakan (No. 31); Tawao (No. 138).

Brotherus attributes smooth cells to *C. tenerum* (he describes *C. subtenerum* from Siam as having papillose cells). Fleischer, however, describes the cells of *C. tenerum* as more or less papillose. Mr. Binstead's No. 31 has papillose cells.

C. Dozyanum, Mitt. Tree, Sandakan (No. 32, f. *elata*); Simporna (No. 131). The former plant is a robust form with stems almost an inch high; a similarly robust form occurs in the British Museum collection. The Simporna plant is a deep green form with the leaves very rigid and scarcely incurved when dry, but I can find no structural differences.

C. hyophilaceum, C. Muell. Tree in jungle, Tenom (No. 156).

C. Geppii, Besch. Coconut palm, Sandakan (No. 36), det. Thériot. This species, so far as I know hitherto only recorded from the original station—an unknown locality—in Java, is much like *C. Dozyanum* in many respects, but differs from it, *inter alia*, in the presence of a teniole. M. Thériot writes that the Sandakan plant only differs, very slightly, from the type of *C. Geppii* in the leaves less spreading when moist, the normal ones with the apex broadly rounded. He adds that Bescherelle describes the teniole of *C. Geppii* as formed of 3–4 rows of cells at the shoulder, and of 5 at the base, while in Mr. Binstead's plant the teniole is narrower at the base (2–3 rows wide); however, the difference is not one of importance, for in Bescherelle's own type-specimen some of the leaves show the teniole equally narrow below.

C. Motleyi, Mitt. Coconut palm, island near Sandakan (No. 37); coconut palm, Sandakan (No. 39); tree, Labuan I. (No. 119).

C. subintegrum, Broth. (Pl. **27**. fig. 9.) Decayed wood in shade, Sekong (No. 79). The leaves in this plant show a rather remarkable form of mamillosity of the upper cells, which are quite smooth at the back, but highly protuberant on the ventral surface, as in the genus *Timmiella*. Brotherus describes the cells as "alte mamillosis" simply, without specifying on which surface, but an original specimen which he has kindly sent me (Siam, *Schmidt*, 1900) shows exactly the structure of the Bornean plant (*cf.* Pl. **27**. fig. 9). Hitherto known only from the original station.

CALYMPERES BECCARII, Hampe. Tree in jungle, Tawao, c.fr. (No. 133). I have compared this with Hampe's specimen leg. Beccari, with which it agrees quite well. The characters of *C. serratum* and *C. Beccarii* as given by Bescherelle, Brotherus, and Fleischer do not altogether agree (as to serrature of margin, leaf-apex, etc.). Nor am I able to find the alleged difference in the form of the cancellina as given by Bescherelle, followed by Brotherus. I am not able, in fact, to arrive at any clear distinction between the two species from the descriptions, beyond the point of size and habit; and am inclined to doubt whether *C. Beccarii* be more than a tall form of *C. serratum*. The fruit appears to agree with that of *C. serratum* as described by Fleischer, except that the ripe capsules are cylindric rather than "länglich ovoidisch," not narrowed below the mouth, and the lid is rather longly subulate (about $\frac{1}{3}$ length of capsule), not "kurz geschnäbelt." These may be characters of importance.

The cancellina of the leaf-base appears in this and *C. serratum* to be often abnormally developed, with the cells small and passing gradually into those of the lamina (or even with the large hyaline cells scarcely developed at all); this is the form figured in the Bryologia javanica, and reproduced in Brotherus (Musci, i. p. 379); but it is certainly not the normal form, in which the cancellina is well developed. The same abnormal condition obtains very frequently in *C. Beccarii*. I have not been able to make out any difference in the outline of the cancellina in the normal leaves of the two species, as given by Brotherus, *op. et loc. cit.*

C. SERRATUM, A. Br. Boulder in stream in shade, Sapong, near Tenom (No. 158).

C. SALAKENSE, Besch. (Pl. **26**. fig. 8.) Coconut palm, Sandakan (No. 29 A). This agrees exactly with Bescherelle's type at the British Museum. Fleischer is no doubt correct in reducing *C. scalare*, Besch. to a synonym of *C. salakense*. Bescherelle's principal characters are the cancellina rows highly scalariform above, and its cells principally quadrate in *C. scalare*, in *C. salakense* the rows very shortly scalariform and the cells for the most part rectangular in shape. Now M. Thériot writes that in Mr. Binstead's plant he has observed the cancellina very shortly, scarcely at all scalariform, with all the upper cells quadrate, in the same leaf.

C. SUBSALAKENSE, Thér. & Dixon, sp. nov. (Pl. **26**. fig. 7.)

C salakensi Besch. affine, sed folii margine in parte basilari multo fortius serrato, cellulisque laminæ multo majoribus 10–15 μ latis.

Hab. Near Tenom (No. 164).

In *C. salakense* (*cf.* Pl. **26**. fig. 8) the cells are very small, 3 μ wide as described by Fleischer—I find them up to 5 or 7 μ in Bescherelle's type;—

here they are two or three times that width; the margin of the sheathing portion is very indistinctly serrulate in *C. salakense*, while here it is markedly serrate. In other respects the plants seem identical.

Calymperes longifolium, Mitt. in Journ. Linn. Soc., Bot. xii. (1868) p. 173.

Syn. *C. loreum*, Lac. (1872).

C. cristatum, Hampe in Nuov. Giorn. Bot. ital. (1878) p. 278.

Rock in jungle, Sapong, near Tenom (No. 160); Sadong, Sarawak, 1900, leg. J. H. Cranston (No. 85).

This remarkable plant has the longest leaves of almost any known species of moss (some species of *Dawsonia* alone, I believe, excepted). Some of the leaves of Mr. Binstead's gathering attain an inch and a half in length. In view of its peculiar structure, it is surprising that Hampe did not recognize the identity between Mitten's species and the plant collected by Beccari and described by him as *C. cristatum*; but Mitten's species—described from Labuan specimens leg. Motley, in his "List of Samoan Mosses"—was probably overlooked by him. As a matter of fact, the two are identical.

Bescherelle separates *C. longifolium* from *C. æruginosum*, Hampe and *C. setifolium*, Hampe by the leaves not being narrowed in the middle; but this is somewhat misleading, since though they are not narrowed conspicuously in the same way as in these species, and are of quite a different character, they do show a distinct constriction above the base, widening out again above for the greater part of their length, and then narrowed to a fine acumen.

Bescherelle has also erred in describing Hampe's *C. cristatum* as having the nerve vanishing below the apex; in Beccari's plant, on the contrary, it is constantly, and in the more elongate leaves long excurrent.

Mr. Binstead's No. 160 shows frequently a curious form of proliferation, a young plant (sometimes more than one) being produced on the upper part of a leaf, and this may be repeated a second time on a leaf of the secondary plant.

POTTIACEÆ.

Gyroweisia brevicaulis (Hampe), Broth.

Syn. *Trichostomum brevicaule*, Hampe in C. Muell. Syn. i. 567.

Didymodon brevicaulis, Fleisch. Musci . . . von Buitenzorg, i. 333.

Coral rock in shade, Simporna, c.fr. (Nos. 1, 128). Not recorded hitherto from Borneo. *Distrib.* Java, New Caledonia.

Hyophila Micholitzii, Broth. Near Tenom (No. 151).

Var. sterilis, Fleisch. Rocks in stream in shade, Sapong, near Tenom (No. 157). Stems lax, not compact; otherwise exactly the plant described by Fleischer.

Both type and var. seem new to Borneo.

TRICHOSTOMUM SARAWAKENSE, Dixon, sp. nov. (Pl. 27. fig. 10.)

Dense, *arcte cæspitosum. robustiusculum*, circa 2 cm. altum, infra fuscum, supra flavo-viride vel glaucescens. Folia *dense conferta*, erecto-patentia, sicca *rigide incurvo-hamata, dorso haud nitida*, subfragilia, majuscula, 3–4 mm. longa, e basi brevissima concava *parum latiore* anguste lingulato-lanceolata, carinato-concava, apice *subacuminato acuto concavo-cucullato* cum costa breviter excurrente pungente, marginibus erectis *supra incurvis*; costa *valida*, apud basin 70–85 μ lata, solida, opaca, nec superne pellucida, dorso prominens, lævis. Cellulæ basilares pellucidæ, infimæ hyalinæ, breviuscule rectangulares, parietibus angustis firmis; supra *sensim minores*, breviores, superiores 8–10 μ, rotundo-hexagonæ, ob papillas minutas densissimas *perobscuræ, opacæ.*

Cetera nulla.

Hab. Sarawak, circa 1913, *I. M. Pearson*; ex herb. G. Webster.

Perhaps most nearly allied to *T. ardjunense*, Fleisch. and *T. subduriusculum*, C. Muell. The former is a smaller plant with leaves only about half the size, the margins not incurved-cucullate at apex, the cells much smaller, while the latter, which scarcely differs from *T. duriusculum*, Mitt., has leaves much more curled and circinate when dry, with a different apex, and the leaf-base widely expanded. The rigidly incurved leaves, not at all glossy at the back when dry, with a very acute, sub-tubular and subcucullate apex having the nerve very shortly and indistinctly excurrent, give the present plant a well-marked character.

BARBULA ZOLLINGERI (Fleisch.), Broth.

Syn. *Trichostomum Zollingeri*, Fleisch. Musci . . . von Buitenzorg, i. 343.

Coral rock, Simporna, c.fr. (No. 127); teste Fleischer. Hitherto recorded only from Java.

B. LOUISIADUM, Broth. Near Tenom, c.fr. (No. 146). Earthy bank, Kudat, c.fr. (No. 161). The fruit has not, I believe, been described. Seta 1 cm. long or less, very slender, pale reddish brown; perichætial bracts erect, somewhat narrower than the leaves, and with longer points; capsule elliptic-cylindric, small, 1–1·5 mm., with a long, subulate lid of equal length; peristome much twisted, almost equal in length to the capsule; columella persistent. New to Borneo.

ORTHOTRICHACEÆ.

DESMOTHECA APICULATA (Doz. & Molk.), Lindb. Tenom, c.fr. (Nos. 154, 162).

MACROMITRIUM MERRILLII, Broth. Kota Balud, Brit. N. Borneo (No. 232). Agrees quite well with Merrill's Philippine Is. plant. New to Borneo.

DREPANOPHYLLACEÆ.

MNIOMALIA SEMILIMBATA (Mitt.), C. Muell. Near Tenom (Nos. 163, 171).

BRYACEÆ.

BRYUM (§Apalodictyon) WEBERÆFORME, Dixon, sp. nov. (Pl. **27**. fig. 11.)

Dioicum videtur; flores masculi haud visi. *Laxe cæspitosum*, gracile, nitidum, circa 1 cm. altum; folia *laxe disposita*, vix comata, erecto-patentia, sicca flexuosa, decurrentia, inferiora late ovato-lanceolata, superiora angustiora, lanceolata, *haud concava*, marginibus omnino planis vel uno latere infimo angustissime recurvato *integerrimis* vel summo apice indistincte sinuoso-denticulatis; costa *tenuis*, infra sæpius rubra, *supra debilis*, *percurrens vel infra apicem evanida*. Cellulæ *anguste lineari-rhomboidales*, ad infimam basin paullo latiores, in angulis decurrentibus laxæ, rectangulæ, omnes parietibus *tenuibus*, subpellucidæ, marginales sensim angustiores, *limbum haud formantes*. Folia perichætialia intima parva, subulato-acuminata; vaginula brevis, turgida; seta ad 2 cm. alta, tenuis, inferne rubra, supra lutescens, theca cernua vel subpendula, e collo longo subcurvulo anguste ovalis, *leptodermica*, *pallida*; operculum conicum mamillatum; annulus bene evolutus. Peristomii dentes pulchre rufo-aurantiaci, oblongo-lanceolati, infra transverse striolati, supra papillosi, lamellis densis extus prominentibus præditi; processus e membrana basilari *prœalta* breves, pallidi, perminute papillosi, valde hiantes, dentibus subæquales; cilia irregularia, sæpius bene evoluta, plusminusve nodosa. Spori perminuti.

Hab. Shaded stony bank by jungle-path, Melalap, near Tenom, 5 May, 1913, c.fr. (No. 165).

A very weberoid-looking species, which indeed I sent to Fleischer queried as *Pohlia* sp. nov.; but it was returned by him as certainly a *Bryum*, and probably a new species. From allied species such as *B. ambiguum*, Duby, *B. weberaceum*, Besch., *B. nitens*, Hook., it differs in the lax habit with distant, flexuose foliation, the very narrow, scarcely percurrent nerve, plane, entire, unbordered, decurrent leaves, etc.

B. CORONATUM, Schwaegr. On coral sand under coconut palms, island near Sandakan, c.fr. (No. 43); sandy banks, Sandakan, c.fr. (Nos. 44, 45); stony bank, Simporna, c.fr. (No. 129).

RHIZOGONIACEÆ.

RHIZOGONIUM MEDIUM, Besch., nov. var. LAXIFOLIUM, Thériot MS. in litt.

Folia minus conferta, paullo angustiora, argutius acuminata.

Hab. Yaté, Küstenwald, New Caledonia, 24 Mar. 1912, c.fr.; leg. Dr. Fritz Sarstin, e Bot. Mus., Zürich. Tree in jungle, Sandakan, leg. Binstead (No. 46).

A form very slightly differing from the typical plant of New Caledonia;

Mr. Binstead's plant quite matches the above cited specimen from the Zürich collection. *R. medium* has not been recorded from Borneo, nor, so far as I am aware, outside New Caledonia.

BARTRAMIACEÆ.

Philonotis revoluta, Bry. jav. Sahad Datu, ♂ (No. 136). Not quite the typical form of the Bryologia javanica, but I think inseparable from that widely spread species. It is not *P. secunda*, according to the distinction given by Fleischer in the perigonial bracts.

P. calomicra, Broth., f. laxifolia, Fleisch. Sandy mud, sides of ditches by road in rubber plantation, Melalap, near Tenom, c.fr. (No. 166); damp stony bank by railway, near Tenom, c.fr. (No. 167), det. Fleischer; Sapong, near Tenom (No. 212 *c*).

WEBERACEÆ.

Webera rupestris (Doz. & Molk.), C. Muell.
Syn. *Diphyscium rupestre*, Doz. & Molk.
Shaded sandstone rock in jungle stream, Sandakan, c.fr. (No. 1).

POLYTRICHACEÆ.

Atrichum Rutteri, Thér. & Dixon, sp. nov. (Pl. **27**. fig. 12.)

Caules erecti, laxe cohærentes, 4–5 cm. alti, flexuosi, simplices, sectione fasciculum centralem magnum exhibentes. Folia sat conferta, infima parva, subsquamiformia, pallida, superiora sola sordide viridia, sensim majora, erecto-patentia, sæpe *ad unum latus spectantia, deflexa, flaccida, haud undulata*, sicca seniora complicata, juniora crispata, superiora ad 6 mm. longa, medio 1·5 mm. lata, e basi paullo dilatata sæpe rufescente late oblongo-lanceolata, concava, apice minime angustato, acutiuscula, submucronata. Costa ad basin longe decurrens, rufa, valida, male limitata, ad 180 μ lata, superne angustior, viridis, dorso lævis, percurrens vix excurrens, *nullo modo lamellata*; sectione in medio folio plano-convexa, e cellulis sat parvis densis omnibus fere homogeneis, dorsalibus modo in unica serie parietibus firmioribus rufo-fuscis instructa; basin versus seriem medianam (sæpe plusminusve duplicatam) ducium, fasciculum dorsalem stereidearum, ventralem minorem stereidearum seu substereidearum, cellulas epidermicas in 1-(hic illic 2-) serie majores plusminusve radiantes, parietibus valde incrassatis purpureis exhibens. Folii margo planus, e medio folio plusminusve (præcipue in foliis superioribus) argute spinulose dentatus, *haud limbatus*. Areolatio peculiaris, e cellulis *irregulariter rotundo-hexagonis* circa 20 μ latis granulosis nec chlorophyllosis dorso lævibus, parietibus *valde sinuosis irregulariter incrassatis collenchymaticis*, ad margines vix

mutatis infra sensim elongatis collenchymatice rectangularibus, infimis elongate laxe rectangularibus, parietibus rectis tenuibus firmis composita. *Dioicum*; flos femineus terminalis, foliis perichætialibus numerosis, eis caulis longioribus patentibus comam formantibus; archegonia numerosa, (20 vel supra) elongata, perangusta, paraphysibus plurimis æquilongis tenerrime filiformibus confertissime intertextis. Cetera desiderata.

Hab. Rundum, 7 May, 1913, leg. E. O. Rutter, D.O. (No. 227).

A remarkable plant, which with its homomallous deflexed leaves, entire absence of lamellæ, and want of fruit, has little to indicate its affinity with *Atrichum* beyond its characteristic stem- and nerve-section, and the general texture and build of its leaves. The areolation also is very peculiar, and recalls some species of the Hepaticæ, or certain austral species of *Pterygophyllum*.

POGONATUM BORNENSE, Thér. & Dixon, sp. nov. (Pl. 27. fig. 13.)

E minoribus generis. Caulis simplex, circa 1 cm. altus; folia caulina densiuscula, suberecta, apice incurvo, *siccitate arcte incurva*, 3 mm. longa, e basi subpellucida parum latiore *breviter late oblonga* (circa 1 mm. lata), *obtusa*, concava; comalia seu perichætialia longiora (5 mm.), angustiora, omnia marginibus erectis, e medio conferte grosse *obtusiuscule*, *prope apicem argutius geminatim denticulatis*. Costa angusta, male limitata, ad basin rufa, supra obscura, circa $\frac{1}{8}$ latitudinis folii, *elamellosa*, dorso lævis. Areolatio ad basin e cellulis longe lineari-rectangularibus pellucidis, parietibus tenuibus, composita, cellulis laminæ obscuris quadrato-rotundis 16–20 μ *latis, parietibus hic illic, præcipue ad angulos incrassatis*, ad marginem superiorem folii sæpe fusco-purpureis. Seta 2 cm. alta, pallide rufa, tenuiuscula; theca subinclinata, parva, oblonga, orificio lato, fusco-viridis, obscure 6-angulata, operculo magno, purpureo, brevi-rostellato. Calyptra pilis densis *albidissimis* obtecta.

Hab. Sandakan, 25 Apr., c.fr. (No. 47), leg. Binstead.

Distinct from all other known species but *P. marginatum*, Mitt. in the entirely elamellose leaves; *P. gymnophyllum*, *P. proliferum*, *P. Warburgii*, which have the lamellæ very much reduced and confined to the surface of the nerve, differ also in the taller habit with loose flexuose foliation. *P. marginatum*, Mitt., from Ceylon, differs entirely in the much more robust habit (stems 5 cm. high or more, leaves lax, flexuose when dry, 5 mm. long), the leaves scarcely at all widened at the base, with the cells remaining short and chlorophyllose, scarcely differentiated, in the basal part, the margin bistratose throughout, almost or quite to the very insertion, and the hairs of the calyptra brown.

A note on one or two specimens of these allied plants may be added. A plant issued by Levier as "*P. hexagonum*, Mitt., Sikkim-Himalaya;

prope Kurseong, Sepagdura Forest, 6800 ped., leg. Decoly & Schaul, 1898," agrees quite well with the type of *P. proliferum*, Mitt. (Surrureem, Griffith, No. 789), at Kew. On the other hand, a plant at Kew, "*P. proliferum* Mitt. det. Mitten 8/91, Bhotan, Griffith, No. 789," is quite different, the leaves being highly lamellose. Probably the identity of the numbers led Mitten to assume identity with the Surrureem plant without careful examination.

NECKERACEÆ.

Endotrichella elegans (Doz. & Molk.), Fleisch. Jungle, Sekong, c.fr. (No. 95). New to Borneo. The descriptions in Dozy & Molkenboer, Musci Frondosi Ined. Arch. Ind., and the Bry. jav. are a little misleading, in stating that the perichætial leaves are gradually tapering and slightly denticulate, and that the cilia are fragile. The perichætial bracts are widely sheathing at the base, and abruptly contracted to a long narrow acumen, and the margin at the point of contraction is coarsely fimbriate-dentate ; while the cilia in old capsules are quite persistent and perfect, and so can hardly be termed fragile, though they are very delicately filiform.

Garovaglia tortifolia, Mitt., from Sarawak, is a true *Garovaglia*, with the capsule immersed in the larger, foliose perichætial bracts.

Garovaglia sp. Base of large tree in jungle, Sekong (No. 185). A sterile species near *G. aristata*, Bry. jav., in very small quantity. It differs from *G. aristata* in the quite nerveless leaves with plane margins, distinct alar cells, subquadrate and enlarged in a small group, and wider upper areolation. It differs from it also, and from all the similar-leaved species in the short apiculus which is dentate throughout. It is probably a new species, but in view of the scanty material I have thought it best to leave it undescribed.

Aërobryopsis longissima (Doz. & Molk.), Fleisch. Jungle, Sekong (No. 96). A slender form.

Floribundaria floribunda (Doz. & Molk.), Fleisch. Rock in jungle, Sapong, near Tenom (No. 178).

Himantocladium loriforme (Bry. jav.), Fleisch. Shaded rocks by stream, Tenom (No. 168). In large mats. "One of the few abundant mosses of N. Borneo," C. H. Binstead in sched.

H. cyclophyllum (C. Muell.), Fleisch. Rock by stream, Sapong, near Tenom (No. 179). A form with the leaves slightly more divergent than in the Javan plant, but otherwise agreeing exactly. Not, I think, hitherto recorded from Borneo.

NECKEROPSIS GRACILENTA (Bry. jav.), Fleisch. Sekong (No. 100); pendulous from rotting stump by jungle-path, in a large sheet, Melalap near Tenom (No. 183).

HOMALIODENDRON GLOSSOPHYLLUM (Mitt.), Fleisch. Jungle, Sekong (No. 110). This agrees quite well with Hooker's Sikkim plant, No. 710, Hb. Ind. Or. Its distribution hitherto has been Eastern Himalayas, Yunnan, Formosa.

HOMALIODENDRON (§Circulifolia) FLEISCHERI, Dixon, sp. nov. (Pl. **27**. fig. 14.)

Caulis primarius tenuis, rigidus; caules secundarii demissi, 3–4 cm. longi, parcissime breviter subpinnatim ramosi, frondem angustam *percomplanatam læte-virentem pernitidam* instruentes. Folia *perfecte complanata*, valde regularia, frondem ad 4–5 mm. latam *sæpius obtusam* rarius flagelliformem formantia, *oblongo-cultriformia*, valde asymmetrica, *pertruncata*, uno margine infra late incurva, e basi perangusta *supra sensim dilatata*, latere antico valde convexa, postico concava, in summo folio (*ubi latitudo maxima*) 1 mm lata, ibique *valde truncata*, medio tantum indistincte obtuse conico-apiculata, tenuiter conferte denticulata, margine convexo obscure crenulato-denticulato, margine concavo integro. Costa simplex, tenuis, $\frac{1}{2}$–$\frac{2}{3}$ folii attingens, apice sæpe dilatata, male delimitata. Areolatio perangusta, cellulæ prope basin lineares, supra sensim breviores, rhomboideæ, summitatis minute breviter ellipticæ; *cellulæ lateris concavi ubique longiores eis lateris convexi.*

Dioicum. Flores masculi parce in axillis foliorum, bracteis perigonialibus rigidis, apicibus obtuse linguatis, divergentibus.

Cetera ignota.

Hab. Shaded rocks in jungle stream, Tenom, 10 May, 1913 (No. 181).

A striking plant, conspicuous by its thin, glossy, fern-like fronds with the leaves very regularly and closely set, and of a very distinct outline, recurved cultriform, the summit widely truncate, almost rectilinear, with only a small median prominence as in some species of *Neckeropsis* (e. g. *N. gracilenta*). The areolation is also remarkable, the cells on the concave side of the leaf being always considerably longer than those of the convex side at the same height; on the former side, in fact, remaining linear almost to the summit.

I sent this plant to Herr Fleischer, queried as *Neckeropsis*; he replied: "181 ist keine *Neckeropsis*! ich könnte sie vorläufig nur bei *Homaliodendron* n. sp. (Circulifolia Gruppe proxim.) unterbringen, jedenfalls ein eigenartiger Typus." I place it provisionally, therefore, under that Section.

THAMNIUM ELLIPTICUM (Bry. jav.), Fleisch. Wet rocks in shade below waterfall, Sapong, near Tenom (No. 170). A good deal water-worn, forming dense mats. Hitherto recorded only from Sumatra and Java.

PINNATELLA MUCRONATA (Bry. jav.), Fleisch. Jungle tree, Sapong, near Tenom (No. 182).

P. MICROPTERA (C. Muell.), Fleisch. Jungle tree, Sapong, near Tenom (No. 212 *a*). A remarkable plant, hitherto only known from the Philippines and Singapore. The leaves are dimorphous, small rounded very concave and not complanate leaves (Brutblätter) taking the place of the normal leaves along the upper part and often at the base of many of the branches, and readily falling away, so as to leave the greater part of many of the branches denuded and bare.

ENTODONTACEÆ.

ERYTHRODONTIUM JULACEUM (Hook.), Par. Jungle, Tenom, c.fr. (Nos. 177, 184).

AUSTINIA MICHOLITZII, Broth., f. MAJOR. Tree near Rest House, Tenom (No. 210); "eine etwas grössere Pflanze als wie die Originalpflanze (forsan sp. nov.), da aber steril kaum als n. spec. zu rechtfertigen," det. Fleischer.

Forming thin wide patches of a deep green, resembling *Amblystegiella serpens*. A new record for Borneo.

HOOKERIACEÆ.

CHÆTOMITRIUM ELONGATUM, Doz. & Molk. Tenom (No. 203); rotting wood, Sapong, near Tenom, c.fr. pauc. (No. 209).

C. BORNENSE, Mitt. in Voy. H.M.S. 'Challenger,' iii. p. 223 in adn.

Syn. *C. Elmeri*, Broth., Musci Novi Philippinense, ii., in Leaflets of Philippine Botany, p. 1974.

Slender twigs in low damp place in jungle, Sapong, near Tenom (No. 175).

A striking and interesting plant, with much the foliation and appearance of *Orthostichopsis tetragona* (Sw.) Broth., of tropical America, as pointed out by Mitten. I at first took the specimen for a *Pilotrichella*, and found it to be identical with a specimen at Kew named "*Pilotrichella perakensis*, Broth. n. sp., Nos. 3550, 3636, Upper Perak, June 1889, leg. J. Wray Jr., Herb. Mus. Perak." On writing to Dr. Brotherus for permission to publish this inedited species, I learnt from him that he had in the meantime obtained fertile specimens from the Philippines, showing it to be a *Chætomitrium*, which he had published as *C. Elmeri*. From Mitten's description of *C. bornense* (a species referred to by Brotherus in the "Musci" as "nicht gesehen"), however, I am convinced that this is the same thing. Mitten's description of that species is almost identical with Brotherus' description of *C. Elmeri*, and there are no points of difference indicated; moreover, the identity of Mr. Binstead's plant with the Perak specimen removes all doubt of the plants all being referable to Mitten's species.

CALLICOSTELLA PAPILLATA (Mont.), Jaeg. Decayed log in shade, Sekong, c.fr. (No. 86).

Var. VIRIDISSIMA (C. Muell.), Dixon, comb. nov. Damp shaded sandy bank, Tenom, c.fr. (No. 172).

This plant appears to be identical with *Callicostella viridissima*, C. Muell. in sched. (*C. pontianacensis*, Par.), from Pontianak; but as the difference from *C. papillata* is confined almost or entirely to the seta, which is papillose in the upper part, I think it should be considered a variety only of this species. Mr. Binstead's plant, at any rate, shows no other distinguishing characters.

C. PRABAKTIANA (C. Muell.), Bry. jav. Sadong, Sarawak, 1900, leg. J. H. Cranston (No. 91).

C. CHLORONEURA (C. Muell.), Fleisch. Rotting wood near stream, Sapong, near Tenom, c.fr. (No. 187). This plant has smooth cells, smooth nerves, leaves very little toothed above, and the seta papillose to the base. It appears, therefore, to agree with C. Mueller's New Guinea plant, which seems to differ from *C. prabaktiana* in precisely these characters—*cf.* M. Fleischer, M. . . . von Buitenzorg, iii. 1023.—It would perhaps be better considered a subspecies of *C. prabaktiana*.

RHACOPILACEÆ.

RHACOPILUM SPECTABILE, Reinw. & Hornsch. Near Tenom (Nos. 169, 173, 174, 180); Rundum, leg. E. O. Rutter, c.fr. (No. 228); Matang, Sarawak, 1899, leg. St. V. Down (No. 23).

LESKEACEÆ.

PELEKIUM VELATUM, Mitt. Jungle, Sekong, c.fr. (No. 113); decayed tree-roots in rubber plantation, Sekong, c.fr. (No. 114); rotting log by stream in shade, Sapong, near Tenom, c.fr. (with *Ectropothecium*, No. 206); Tabetang, near Sadong, Sarawak, 1901, leg. Rev. — Moore.

THUIDIUM TRACHYPODUM (Mitt.). Shaded rocks by stream, Tenom, c.fr. (No. 193).

T. PLUMULOSUM (Doz. & Molk.), Bry. jav. Rock in jungle-stream, Tenom (No. 188); rotting wood near stream in shade, Sapong, near Tenom (No. 189); rock by stream in shade, Sapong, near Tenom (Nos. 190, 192).

T. GLAUCINOIDES, Broth. Rock near waterfall, Sapong, near Tenom, ♂ plant (No. 191). This has a very distinct appearance, having the

secondary branchlets very frequently suppresed, so that the stem appears pinnate only or slightly bipinnate, not frondose as usual; but some stems are quite normal, and show it to be a state merely.

HYPNACEÆ.

CTENIDIADELPHUS SPINULOSUS (Broth.), Fleisch. MS. (*Campylium spinulosus*, Broth. in sched.). Jungle, Sekong, c.fr. (Nos. 97, 109), det. Fleischer. This is an undescribed species, for which, with *Hypnum Plumularia*, C. Muell., Fleischer proposes the new genus *Ctenidiadelphus.*

ECTROPOTHECIUM, Mitt.

This large and very difficult genus reaches one of its culminating points in the Western Pacific; a large number of species have been described in recent years, and I have received several from the Solomon Is, New Hebrides, and elsewhere which I am not able to refer at present to any species known to me. The absence of fruit also frequently renders it unsafe to attempt determination. I have thought it best to leave one or two of Mr. Binstead's plants undetermined for this reason.

E. MORITZII (C. Muell.), Jaeg. Shaded rocks near stream, Sapong, near Tenom, c.fr. (No. 202); Rundum, leg. E. O. Rutter (No. 231); Sadong, Sarawak, leg. J. H. Cranston, 1901 (No. 49).

E. DEALBATUM (Hornsch. & Reinw.)? Damp rocks by railway, near Tenom (No. 195). A doubtful plant. According to a letter received from Fleischer, several different plants figure in the herbaria under this name. I sent this (No. 195) to him with another specimen from Coconut I., near Sandakan c.fr. (No. 59), upon which plants he writes that No. 59, *E. dealbatum?* is not identical with the *Hypnum dealbatum* of the Bry. jav., nor with *H. dealbatum* of C. Mueller's Synopsis, nor with *E. dealbatum* ex herb. Mitt. from Toegoe (Java), with which latter Mr. Binstead's No. 195 agrees. But which of these accords with the original of Reinwardt is uncertain, and can only be settled by comparison with that author's own specimens, which he has so far been unable to see.

ECTROPOTHECIUM sp. Coral rock, Simporna, c.fr. (Nos. 130, 132). Very near No. 59 (*E. dealbatum?*), but slightly more robust, the leaves rather broader, less finely pointed, perichætial leaves rather longer and finer.

E. MONUMENTORUM (Duby), Jaeg. Decayed tree-roots, rubber plantation near Sandakan, c.fr. (Nos. 51, 61); Coconut I., near Sandakan, on coral sand in shade, c.fr. (No. 137); rotting log by stream in shade, Sapong, near Tenom, c.fr. (No. 206).

Mr. Binstead's specimens agree with one another in the length of the seta (1 cm.) and the very small capsule. No. 51 is slightly larger than the others, with a tendency to a reddish colour, and with longer points to the leaves, but a similar seta and capsule.

According to the Bryologia javanica, *E. Chamissonis* (Hornsch.) differs from *E. monumentorum* in the colour (sulphureo et æruginoso), the seta three times as long, and the capsule (minutissimum omnium). But Hornschuch's own specimens in Herb. Wils. at the British Museum have two setæ, each certainly not more than 1 cm. in length; the single intact capsule is very small, the colour of the plant golden yellow to yellowish green. While Beccari's plant from Borneo, determined as *H. Chamissonis* by Hampe, has the darker green colour, very short seta (5–7 mm.) of *monumentorum*, with the minute capsule of *Chamissonis*. The figures in the Bryologia javanica of *H. Chamissonis* show a distinctly longer seta, and it is difficult to get over this; but there is little else in the figures to suggest any difference, and in view of the above facts in regard to Hornschuch's plant and Beccari's, I incline to think the two species must be united. In any case I should place Beccari's plant under *E. monumentorum*.

Ectropothecium verrucosum (Hampe), Jaeg. Shaded stony bank in jungle, Melalap, near Tenom, c.fr. (No. 199).

E. Zollingeri (C. Muell.), Jaeg. Near Tenom, c.fr. (Nos. 198, 200). Boulder in stream in shade, Sapong, near Tenom, ♀ (No. 205). This latter is no doubt the sterile female plant referred to in the Bryologia javanica as collected by Teyssman, agreeing in all respects with the ordinary form but bearing ♀ flowers only.

E. scaberulum, Broth. ined. Damp rocks by railway, near Tenom, c.fr. (No. 195 pp.), det. Fleischer. Matang, Sarawak, leg. St. V. Down, 1899, ex herb. Binstead (No. 21). The Tenom plant was detected by Fleischer among stems of the *Ectropothecium* (No. 195) referred to above, and I subsequently found several more stems, some fruiting. The Matang plant, which I received as *E. sarawakense*, Broth. n. sp., is I think certainly identical with the Tenom plant, and both agree with the Sarawak plant, leg. Micholitz, 1903, on which Brotherus based his *E. scaberulum*.

I also refer to the same species a plant gathered by Steel in the Fiji Is., and sent to me by Mr. W. Ingham.

E. subichnotocladum (C. Muell.), Fleisch. ined. Rocks in railway-bank near Tenom, ♀ (No. 196); det. Fleischer.

ECTROPOTHECIUM sp. Jungle, Sekong, sine fructu (No. 107). A species near *E. subverrucosum* (Geheeb) and *E. Micholitzii*, Broth., but being without fruit its position cannot be certainly determined. It appears to be polyoicous ; M. Thériot has found synoicous flowers, and I have seen some stems wholly male, and some with perichætia but no male flowers.

ECTROPOTHECIUM sp. Damp rock in jungle, Sapong, near Tenom (No. 211 A). A very delicate plant which may possibly be an *Isopterygium*, but probably a species of *Ectropothecium* ; leaves quite complanate, widely oval, with rather wide cells. Dioicous, sterile ♀ plants only. With *Plagiothecium Miquelii.*

ECTROPOTHECIUM DIXONI, Fleisch., sp. nov. MS. in litt. (Pl. **27.** fig. 15.)

E. Moritzii affine, *robustius, læte-viride vel luteo-viride*, caulibus elongatis *dense pinnatis, ramis ad* 1 *cm. fere longis.* Folia magna, omnia, præcipue caulina, siccitate *plusminusve striato-plicata*, eis *E. Moritzii majora*, basi *latiore auriculata supra plicato-rugulosa*, nervis binis validiusculis ; cellulæ alares *numerosæ, laxæ, magnæ, hyalinæ, auriculas magnas bene notatas* instruentes ; folia ramea subsimilia, longe acuminata, *valde falcata, omnia grosse serrata.* Dioica ; flores feminei ma ni, bracteis *stellatim patentibus* e basi brevi sensim in acumen longum validum lanceolato-loriforme grosse dentatum angustatis. Reliqua ignota.

Hab. Decayed log in shade, Sekong, 23 Apr. 1913 (No. 108).

Distinct in its robust habit, pale colour, large, plicate leaves with wide bases and numerous hyaline alar cells ; the perichætia also are distinct.

TRISMEGISTIA LANCIFOLIA (Harv.), Broth. Baram, N.W. Borneo, Bishop Hose (from a monkey-skin in the British Museum), cum setis (Nos. 107, 109). Mt. Dulit, comm. F. J. Chittenden.

T. RIGIDA (Reinw. & Hornsch.), Broth. Rundum, leg. E. O. Rutter (Nos. 229, 230).

ISOPTERYGIUM TEXTORI (Lac.), Mitt. Shaded stones on bank in jungle, and earthy bank beside path, Sapong, near Tenom (Nos. 176, 186).

I. MINUTIRAMEUM (C. Muell.), Jaeg. Decayed tree-roots in rubber plantation, Sandakan, c.fr. (No. 63); decayed wood, Sekong, c.fr. (No. 102). The Bryologia javanica figures the capsules as pendulous or sub-pendulous, and somewhat elongate ; I find them to vary a good deal even on the same tuft in both Ceylonese specimens and the above plants ; they may be pendulous, short, symmetrical, in fact quite Ectropothecioid, or horizontal, elongate, slightly curved and asymmetrical.

ISOPTERYGIUM ALBESCENS (Schwaegr.), Jaeg. Decayed tree-stumps, sandy ground about tree-roots, etc., Sandakan, c.fr. (Nos. 49, 55, 57, 65); roots of coconut palm, Labuan, c.fr. (No. 116); Sibetic Is., c.fr. (No. 125).

I. BANCANUM (Bry. jav.), Jaeg. Shaded damp bank by jungle path, Melalap, near Tenom, a robust form, with capsules larger than usual, c.fr. (No. 194); shaded sandy bank near Tenom, c.fr. (No. 201), somewhat less robust.

PLAGIOTHECIUM MIQUELII (Bry. jav.), Broth. Damp shaded rock in jungle, Sandakan (No. 53); damp rock in jungle, Sapong, near Tenom, c.fr. (Nos. 211, 212).

Two other plants I refer here with some hesitation, viz. from jungle, Sekong, c.fr. (No. 99); and decayed wood, Sekong, c.fr. (No. 106). The same thing has been issued by Levier as *P. Miquelii*, "Borneo, leg. Ledru, det. C. M., no. 2316." They represent a very pale, glossy plant with much denser, less complanate foliation than in normal *P. Miquelii*, having lax vesicular cells at the junction of the leaves with the stem, and a comparatively lax stem cortex, and have thus a very different aspect, combined with certain not unimportant structural characters. The peripheral stem cells of *P. Miquelii* (*e.g.* from Sumatra, leg. Beccari, 1878, in Herb. Kew.) are very narrow and linear. A specimen in Herb. Hampe. in the Brit. Mus. collection, "Banca, leg. Kurz & Lacoste," has the usual thin, sub-complanate phyllotaxy, and colour of *P. Miquelii*, but the cortical cells of the stem are slightly wider than in the normal plant, and the foliation is a little denser; while Mr. Binstead's No. 99 is also slightly intermediate. All have, moreover, the very characteristic perichætial bracts of this species, and it is perhaps best to keep the plants in question under *P. Miquelii*. I should add, however, that M. Thériot is inclined to look upon it as a distinct species, and points out certain other distinguishing characters in the form of capsule, etc.; but I am not clear that these characters are constant, and am at present disposed to retain the plants here.

TAXITHELIUM SELENITHECIUM (C. Muell.), Par. Decayed wood in shade, Sekong, c.fr. (No. 111), det. Fleischer. Found also with Nos. 101 and 108 from the same locality.

T. ISOCLADUM (Bry. jav.), Broth. Small tree in jungle, Sandakan, c.fr. (No. 62); Sekong (with *Aërobryopsis longissima*, No. 96).

T. PAPILLATUM (Harv.), Broth. Decayed wood in jungle, Sandakan, c.fr. (Nos. 50, 54 *a*, 64); decayed wood in shade, Sekong (Nos. 103, 111); Sadong, Sarawak, leg. J. H. Cranston, 1900 (Nos. 48, 112).

TAXITHELIUM (Monostigma) SUBINTEGRUM, Broth. & Dixon, sp. nov. (Pl. **27**. fig. 16.)

T. papillato affine, sed foliis *confertioribus imbricatis* subnitidis *multo brevius acuminatis perconcavis* e basi angustiore oblongis *breviter nec tenuiter acutatis* prope apicem *concavo-carinatis marginibus late reflexis* enerviis, marginibus *integris vel minime indistincte denticulatis*; cellulis alaribus trinis, vesicularibus flavidis, ceteris *ubique angustissime linearibus* incrassatis, dorso uni-papillatis, papillis majusculis sed illis *T. papillati* minoribus. Autoicum. Bracteæ perichætiales numerosæ, e basi latiore *lanceolato-loriformes, grosse dentatæ*. Seta 1·5 cm. vel paullo ultra, ubique lævis. Theca *pendula*, parva, *breviter turgide ovalis*, fusca.

Hab. Baram, N.W. Borneo, leg. Bp. Hose (No. 110), taken from inside a monkey-skin at the British Museum; comm. W. R. Sherrin.

T. papillatum is very variable in its leaf form and arrangement, sometimes showing a marked dimorphism of the leaves on the same plant, some branches having them subcomplanate, wide, abruptly filiform-acuminate, with wide rhomboidal cells, while on others they are imbricated, gradually attenuated, with narrower linear-rhomboidal areolation. The present plant differs from all forms of that widely distributed species in the shortly and rather stoutly pointed leaves, entire or nearly so, the strongly toothed, almost runcinate perichætial bracts, oval pendulous capsule, etc. The papillæ on the leaves are very unevenly distributed, sometimes very dense, at others extremely sparse; always smaller and less conspicuous than in *T. papillatum*. The form of the leaf at the base of the acumen is very characteristic.

VESICULARIA DUBYANA (C. Muell.), Broth. Rotting wood, Sapong, near Tenom, c.fr. (No. 209 *a*); Tabekang, near Sadong, Sarawak (No. 60), and Sadong, c.fr. (No. 66), leg. Rev. — Moore, 1901.

V. INFLECTENS (Brid.), C. Muell. Railway-bank, Tenom (No. 212 *b*). M. Thériot, to whom I submitted this, considers it to be the above species, in spite of some very minor differences; with this I quite concur.

MEIOTHECIUM MICROCARPUM (Harv.), Mitt. Coconut palm, Labuan I., Borneo, c.fr. (No. 117); coconut palm, Tawao, c.fr. (No. 134).

M. JAGORI (C. Muell.), Fleisch. Tree at edge of jungle by railway, near Tenom (No. 197), det. Fleischer.

TRICHOSTELEUM HAMATUM (Doz. & Molk.), Jaeg. Decayed wood in shade, Sekong, c.fr. (Nos. 101, 112); rotting wood in shade near stream, Sapong, near Tenom, c.fr. (No. 208).

T. ÆQUOREUM, Fleisch. ined. Decayed wood in shade, Sekong (Nos. 104, 115). A small, dense, pale, sterile plant, much like *T. hamatum*, but much

smaller and apparently dioicous; it agrees with "*T. æquoreum* Fleisch. n. sp., Bismarck-Archipel, Insel Mioko, M. Frond. Arch. Ind. et Polynes., No. 446," in all respects, the leaves only being possibly a shade less falcate.

TRICHOSTELEUM LUXURIANS (Doz. & Molk.), Broth. Wet clay bank by brook, Sandakan, c.fr. (No. 60); Sekong, on decayed wood, c.fr. (No. 105, and with *T. hamatum*, No. 101).

SEMATOPHYLLUM CONVOLUTUM (Bry. jav.), Jaeg. Sadong, Sarawak, 1901, leg. J. H. Cranston, c.fr. (No. 65).

S. LAMPROPHYLLUM (Mitt.), Jaeg. (*S. scabrellum* (Bry. jav.), Par.). Damp rock in jungle, Sapong, near Tenom (No. 211 B). Associated with *Plagiothecium Miquelii*, etc. I have not been able to see an authentic specimeu of *S. scabrellum*, Lac., but from the description and figures this agrees very well. It is closely associated also with a somewhat different looking plant with wider leaves, which, however, I believe intergrades with it and is the same species. Both occurred in very small quantity.

Cardot, in Ann. Conserv. Genève, xv.–xvi. 175 (Plantæ Hochreutineranæ), has shown that *Acroporium lamprophyllum*, Mitt. (1867) antedates and is identical with *H. scabrellum*, Bry. jav. It is necessary not to confuse this plant, *Sematophyllum lamprophyllum* (Mitt.) Jaeg., with *S. lamprophyllum*, Mitt. from Cuba; but as that species is referable to *Rhaphidostegium* there is no reason why the two names should not stand.

S. BRAUNII (C. Muell.), Jaeg. Matang, Sarawak, 1899, leg. J. H. Cranston, 1901 (No. 84).

SEMATOPHYLLUM RIGENS, Broth. MS. in litt. ad Rev. C. H. Binstead, sp. nov. (Pl. **27**. fig. 18.)

Robustum; caulis ad 5 cm. altus, parce irregulariter ramosus, flexuosus, rigidus, *olivaceus*. Folia sat conferta, *rigidissima, sicca haud mutata*, erecto-patentia vel aliquando secunda, *stricta*, ad summum caulem penicillata, vix tamen cuspidata, 5 *mm. longa vel supra, totum folium convoluto-concavum, superne tubulosum, a basi ad apicem acutiusculum pungentem sensim angustatum*, integerrimum, enerve. Cellulæ angustissimæ, lineares, sæpe subvermiculares, læves, parietibus firmis incrassatis, infra majores, valde porosæ, infimæ aurantiacæ, alares magnæ, vesiculosæ, circa quinæ, auriculas magnas pernotatas formantes. Cetera nulla.

Hab. Matang, Sarawak, *St. V. B. Down*, 1899, ex herb. Binstead.

Quite distinct from all the species known to me in the robust habit with long, narrow, rigid, subulate-tubular leaves. *S. secundum* (Reinw. & Hornsch.) is perhaps the nearest, but that has the leaves quite differently disposed, and with a distinctly expanded base; here the leaves are subtubular and convolute from the insertion, as in some of the smaller species.

SEMATOPHYLLUM DOWNII (Broth.), Dixon, sp. nov. (*Trichosteleum Downii*, Broth. MS. in litt. ad Rev. C. H. Binstead.) (Pl. **27**. fig. 17.)

Dioicum videtur. Sat robustum, dense cæspitosum, ochraceum, circa 3 cm. altum, nitidiusculum, ramosum, apice falcatum. Folia sat conferta, *regulariter secunda, sæpe pulchre falcato-secunda*, 2 mm. longa, pallida, *e basi ovato-lanceolata anguste longe convolutacea subulato-acuminata*, acuta, integra vel apice subdenticulata, enervia, supra ob cellularum parietes prominentes sæpe indistincte subrugulosa. Areolatio normalis, ad infimam basin sæpe lutea; cellulæ alares hyalinæ, magnæ, vesiculares, *sat teneræ*. Perichætium parvum, bracteis e basi late ovata *raptim in acumen æquilongum basi eroso-dentatum* contractis. Seta tenella, 1·25 cm. alta, lævis vel ad apicem indistincte rugulosa; theca minuta, subpendula, collo abrupto *paullo tuberculoso*, operculo subulato, subæquilongo.

Hab. Matang, Sarawak, *St. V. B. Down*, 1899, ex herb. Binstead.

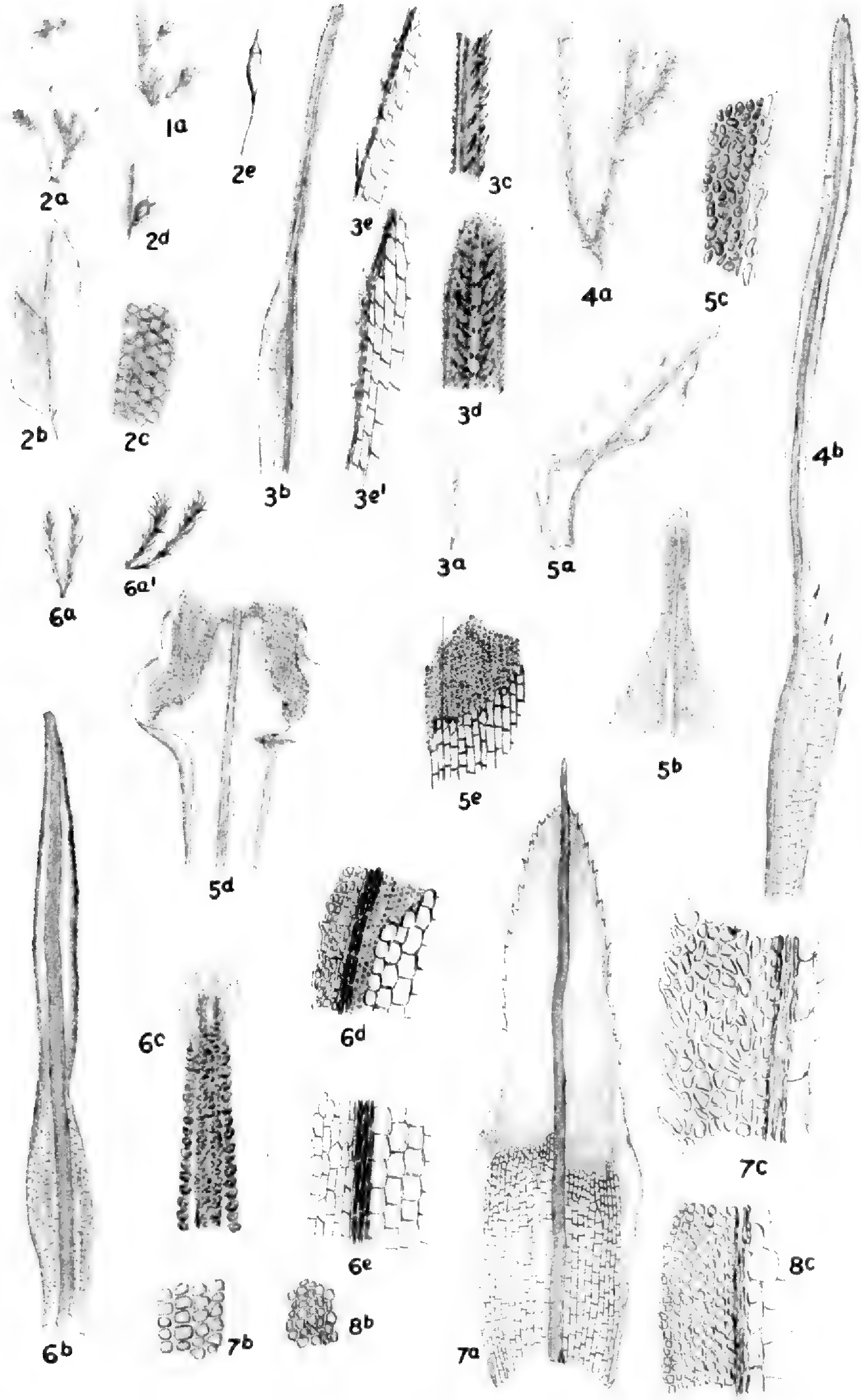
This was determined by Brotherus as *Trichosteleum Downii*, n. sp., but it appears to me to be a *Sematophyllum*. It is near to an unpublished species "*Acroporium falcatulum*, Fleisch., No. 492 M. Frond. Archip. Ind.," from West Java (nec *Sematophyllum falcatulum*, Broth. in Hedw. Bd. 50, p. 144), but that is a more slender, less cæspitose plant, with the upper cells apparently quite smooth, and a somewhat different form and structure of the leaf-base. *S. falcifolium*, Fleisch. ined., has a quite different habit and branching, shorter leaf-points and different fruit.

I have found no ♂ flowers or plants, and though the specimen is richly fruiting, I believe it to be dioicous.

S. PALANENSE (Hampe), Broth. Decayed wood in jungle, Sandakan, c.fr. (Nos. 52, **54** B, 58). There are no specimens of the Bornean *S. palanense* in Hampe's herbarium, but the description fits the above plants admirably.

PILŒCIUM PSEUDO-RUFESCENS (Hampe), C. Muell. Tree in jungle, Sandakan (No. 56).

RHYNCHOSTEGIUM VAGANS (Harv.), Jaeg. Rotting wood below waterfall, Sapong, near Tenom (No. 207). Not hitherto recorded, I believe, from Borneo. It agrees quite well with the Indian plant, which extends eastward to Java, Ceram, and Ternate.



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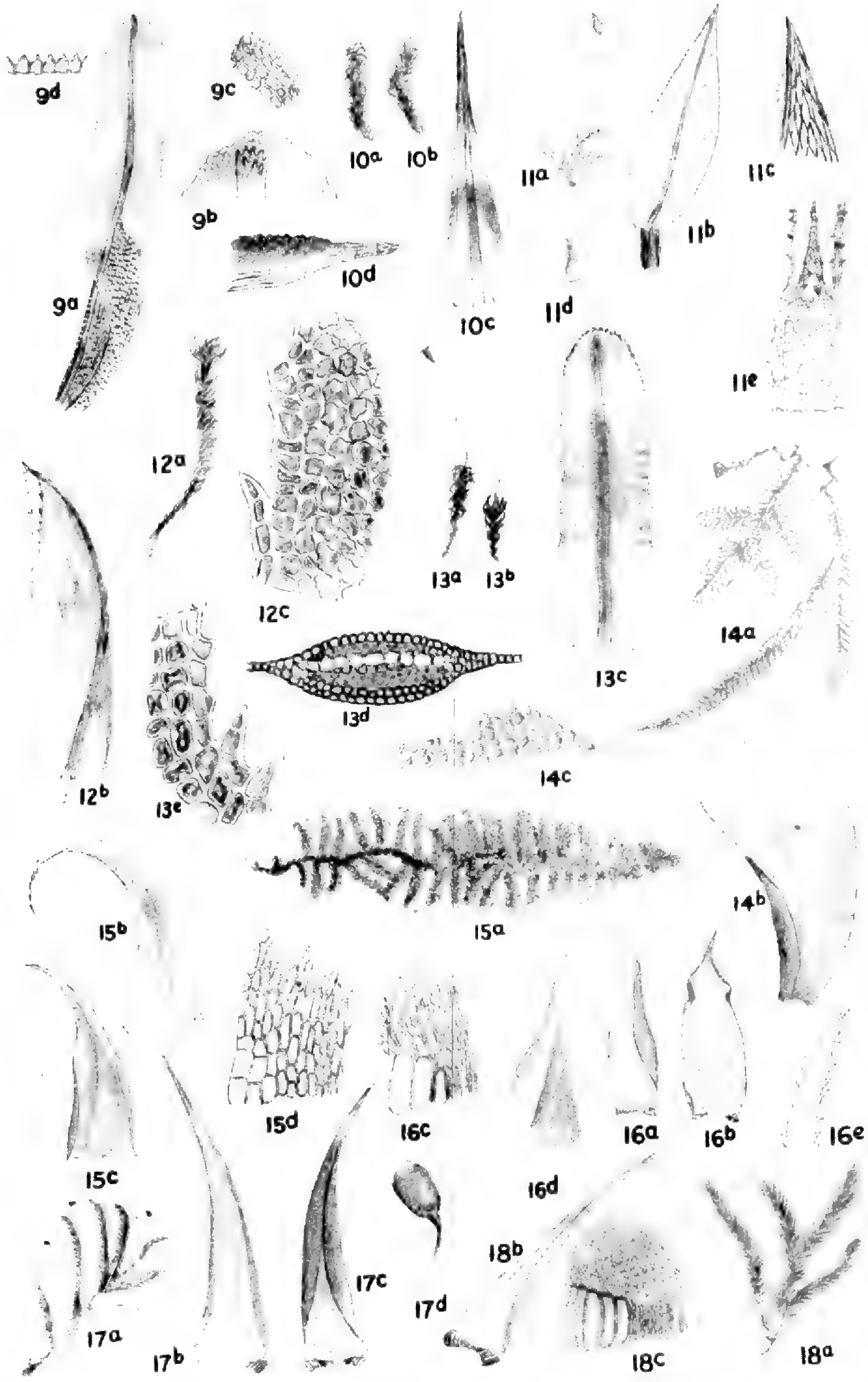
BORNEAN MOSSES.



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BORNEAN MOSSES.

EXPLANATION OF THE PLATES.

Plate 26.

Fig. 1. ***Wilsoniella tonkinensis***, Besch. (Binstead, No. 7). *a*, male plant × 4.

Fig. 2. ***Fissidens autoicus***, Thér. & Dixon. *a*, plant, nat. size; *b*, leaf × 20; *c*, upper cells × 200; *d*, male flower × 8; *e*, capsule × 8.

Fig. 3. ***Syrrhopodon Ledruanus***, C. Muell. (leg. Ledru). *a*, stem, moist, nat. size; *b*, leaf × 20; *c*, upper part of leaf, showing spiculose nerve (right) and papillæ of lamina (left) × 50; *d*, leaf-apex × 50; *e*, *e'*, margin at shoulder × 50.

Fig. 4. ***Syrrhopodon patulifolius***, Thér. & Dixon. *a*, stem (moist), *a'*, do. (dry), nat. size; *b*, leaf × 20.

Fig. 5. ***Syrrhopodon Binsteadii***, Thér. & Dixon. *a*, leaf × 20; *b*, leaf-apex × 50; *c*, upper cells × 200; *d*, base of leaf × 40; *e*, shoulder, etc. of leaf-base × 60.

Fig. 6. ***Syrrhopodon tuberculosus***, Thér. & Dixon. *a*, stem (left moist, right dry), nat. size; *b*, leaf × 20; *c*, leaf-apex × 100; *d*, margin of base at shoulder × 150; *e*, do. at mid-base × 150.

Fig. 7. ***Calymperes subsalakense***, Thér. & Dixon. *a*, leaf × 20; *b*, upper cells × 200; *c*, margin of base at shoulder × 40.

Fig. 8. ***Calymperes salakense***, Besch. (Java, leg. Schiffner, ex herb. Besch.). *b*, upper cells × 200; *c*, margin of base at shoulder × 40.

Plate 27.

Fig. 9. ***Calymperes subintegrum***, Broth. (Binstead, No. 79). *a*, leaf, flattened out, × 10; *b*, leaf-apex × 100; *c*, upper cells × 200; *d*, do., in transverse section of leaf, × 200.

Fig. 10. ***Trichostomum sarawakense***, Dixon. *a*, stem (dry), *b*, do. (moist), nat. size; *c*, leaf × 10; *d*, leaf-apex × 100.

Fig. 11. ***Bryum weberæforme***, Dixon. *a*, plant, nat. size; *b*, leaf × 20; *c*, leaf-apex × 50; *d*, capsule × 2; *e*, portion of inner peristome × 50.

Fig. 12. ***Atrichum Rutteri***, Thér. & Dixon. *a*, ♀ stem, nat. size; *b*, stem-leaf × 10; *c*, upper cells × 200.

Fig. 13. ***Pogonatum bornense***, Thér. & Dixon. *a*, stem (dry), *b*, do. (moist), nat. size; *c*, leaf × 10; *d*, leaf-section in upper part × 80; *e*, upper cells × 200.

Fig. 14. ***Homaliodendron Fleischeri***, Dixon. *a*, stem, nat. size; *b*, leaf × 20; *c*, apiculus and cells × 200.

Fig. 15. ***Ectropothecium Dixoni***, Fleisch. *a*, stem, nat. size; *b*, stem-leaf, *c*, branch-leaf, × 20; *d*, alar cells × 100.

Fig. 16. ***Taxithelium subintegrum***, Broth. & Dixon. *a*, *b*, leaves × 20; *c*, alar cells × 50; *d*, leaf-apex × 50; *e*, apex of perichætial bract × 50.

Fig. 17. ***Sematophyllum Downii*** (Broth.). *a*, stem, nat. size; *b*, *c*, leaves × 20; *d*, capsule × 10.

Fig. 18. ***Sematophyllum rigens***, Broth. *a*, part of stem, nat. size; *b*, leaf × 10; *c*, alar cells × 50.

On the Brown Seaweeds of the Salt Marsh.—Part II. Their Systematic Relationships, Morphology, and Ecology.

By Sarah M. Baker, D.Sc., F.L.S., Quain Student at University College, London, and Maude H. Bohling [afterwards Blandford], B.Sc., Fulneck School, Leeds.*

(Plates 28–30, and 18 Text-figures.)

[Read 6th May, 1915.]

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GENERAL INTRODUCTION.

THE very luxuriant and extensive undergrowth of *Pelvetia canaliculata* v. *libera* found by Prof. F. W. Oliver (Oliver, in Tansley, 1911, p. 364) in the great *Salicornia* marsh at Blakeney Point, Norfolk, has already drawn the attention of one of us (Baker, 1912) to the possibilities of the salt marsh as a habitat for Brown Algæ. A somewhat analogous association has been recognised by Cotton on the Peat Marshes in Achill Sound and Bellacragher Bay, W. Ireland (Cotton, 1912, p. 80), in which a minute form of *Fucus*, *F. vesiculosus* v. *muscoides*, Cotton, forms a dense mossy carpet with *Glyceria*, *Armeria*, and *Salicornia*. Cotton has also especially noticed the associations of Brown Algæ, *Fucus volubilis* and *Ascophyllum nodosum* v. *minor*, occurring in great profusion on the salt marshes between Keyhaven and Hurst Castle, Hants, among *Spartina Townsendii* (Cotton, in Morris, 1914, p. 192).

It is evident that the occurrence of the larger Brown Algæ on salt marshes is by no means occasional or accidental, and the investigations to be described in the present paper have been directed primarily to a study of the effects of the physical conditions, characteristic of the salt-marsh habitat, upon the morphology of these normally rock-dwelling Algæ. The causes of the great changes in morphology induced by this change of habitat have been

referred by other writers (Arcichovskij, 1905; N. Svedelius, 1901, p. 85) to degeneration produced progressively by long-continued vegetative reproduction under these conditions. Although inherent effects of this kind have undoubtedly some influence in altering the habit of such plastic organisms as the Algæ, the evidence we have collected goes to show that the most striking morphological peculiarities of the salt-marsh forms are evoked as a direct response to the new physical and chemical conditions of the habitat.

It was necessary, however, before any idea could be obtained of the change in morphology produced in any one species under the new conditions, to establish very definitely the genetic relationships between the various salt-marsh forms and the corresponding rock species. As Cotton (1912, p. 125) has already pointed out, the nomenclature, especially of the dwarf forms of *Fucus*, so common on salt marshes, is in a state of chaos, no two authors agreeing as to the status, form, variety, or species, of these peculiar plants. The first part of this paper will be devoted to a consideration of the systematic status and relationships of the British Fucoids which have been reported from salt marshes, and will include a description of a new salt-marsh variety, derived from *Fucus ceranoides*, found at Keyhaven, Hants. The second part of the paper will deal more particularly with the relations between the physical factors operating in the salt marsh and the morphological peculiarities of salt-marsh Fucoids; while the third part will give a short account of the relative distribution of the Fucoids and the other Algæ of the salt marsh, and their special functions in the autonomy of the marsh, in certain areas which have come under our own observation.

PART 1.

Systematic Position of the Marsh Fucoids.

The Rock Fucoids.

On the coasts of the British Isles we have six common species of the Fucoideæ characteristic of the littoral region of sheltered rocky shores; these are given in descending order of altitude:—

Pelvetia canaliculata (L.), Decne & Thur.
Fucus spiralis, L. (=*platycarpus*, Thur.).
Ascophyllum nodosum (L.), Le Jol. } Relative height varies
Fucus vesiculosus, L. } in different localities.
Fucus serratus, L.
Also *Fucus ceranoides*, L., characteristic of brackish water.

On exposed coasts *Himanthalia lorea* replaces *Ascophyllum* (see Cotton, Clare Island, p. 38).

Most systematists regard these six species as thoroughly well established, despite the fact that many varieties are known of the four *Fuci*, which show transition forms, connecting the species. Recently, however, the validity of the three species, *F. spiralis*, *ceranoides*, and *vesiculosus*, has been questioned; first, by J. Chalon (1904–1905), and, later, by Stomps (1911), who has collected a mass of interesting evidence in support of his contention that they are to be regarded as adaptational varieties of one species.

It is well to restate the fundamental distinctions between the species. Between *Fucus spiralis* and *vesiculosus* the only reliable diagnostic character is that the former is hermaphrodite and the latter diœcious. When present, the round hard vesicles of *F. vesiculosus* are peculiar to that species; but they should not be confounded with irregular, soft, blister-like swellings, which appear frequently on all three species, especially in brackish water. *F. ceranoides* may be either hermaphrodite or diœcious; but its delicate thallus and the corymbiform arrangement of the receptacles are very characteristic. No transitions have been found between the diœcious and hermaphrodite condition comparable to those found in the marsh *F. ceranoides* (see p. 343), which certainly would have been found in transitional varieties if only a single species were concerned. In spite of individual variability, there is no reason to doubt the validity of any of the species listed.

The Relation of Marsh Species to Rock Species.

It is a tolerably safe axiom to adopt, that all the Fucoids found on salt marshes and in analogous associations have been derived primarily, at a more or less remote epoch, from rock species. This leads to two general questions:—

(1) Are the marsh and loose-lying Fucoids to be regarded as distinct species, or merely as peculiar varieties or forms of the rock species?

(2) Which of the rock species is the ancestor of each marsh species?

The two questions are interdependent, and will be answered by considering each species represented on the marsh in detail.

The Marsh Forms of Pelvetia.

Pelvetia canaliculata, varr. libera, *S. M. Baker*, radicans, *Foslie*, et coralloides, *S. M. Baker*.

These striking salt-marsh algæ, one of which (the var. *libera*) forms an undergrowth with *Salicornia europæa* over extensive areas in the Blakeney marshes, have already been discussed in some detail by one of us (Baker, 1912). Their form is not very divergent from typical rock *Pelvetia*, the chief peculiarities being the absence of sexual reproduction, the curling of

the var. *libera*, and the dwarfing of the two embedded varieties. These are evidently correlated with the marsh habitat.

The Marsh Forms of Ascophyllum.

ASCOPHYLLUM NODOSUM, var. SCORPIOIDES, *Hauck*, var. MACKAII, *Cotton*, and var. MINOR, *Turn.*

The first two algæ are in some ways the most interesting of all the Marsh Fucoids. The first is usually found embedded in the mud; but seems to be identical with the var. *scorpioides*, produced in the loose-lying associations characteristic of the Baltic. The relationships of these associations with those of the salt marsh will be discussed later (p. 339). There is no question

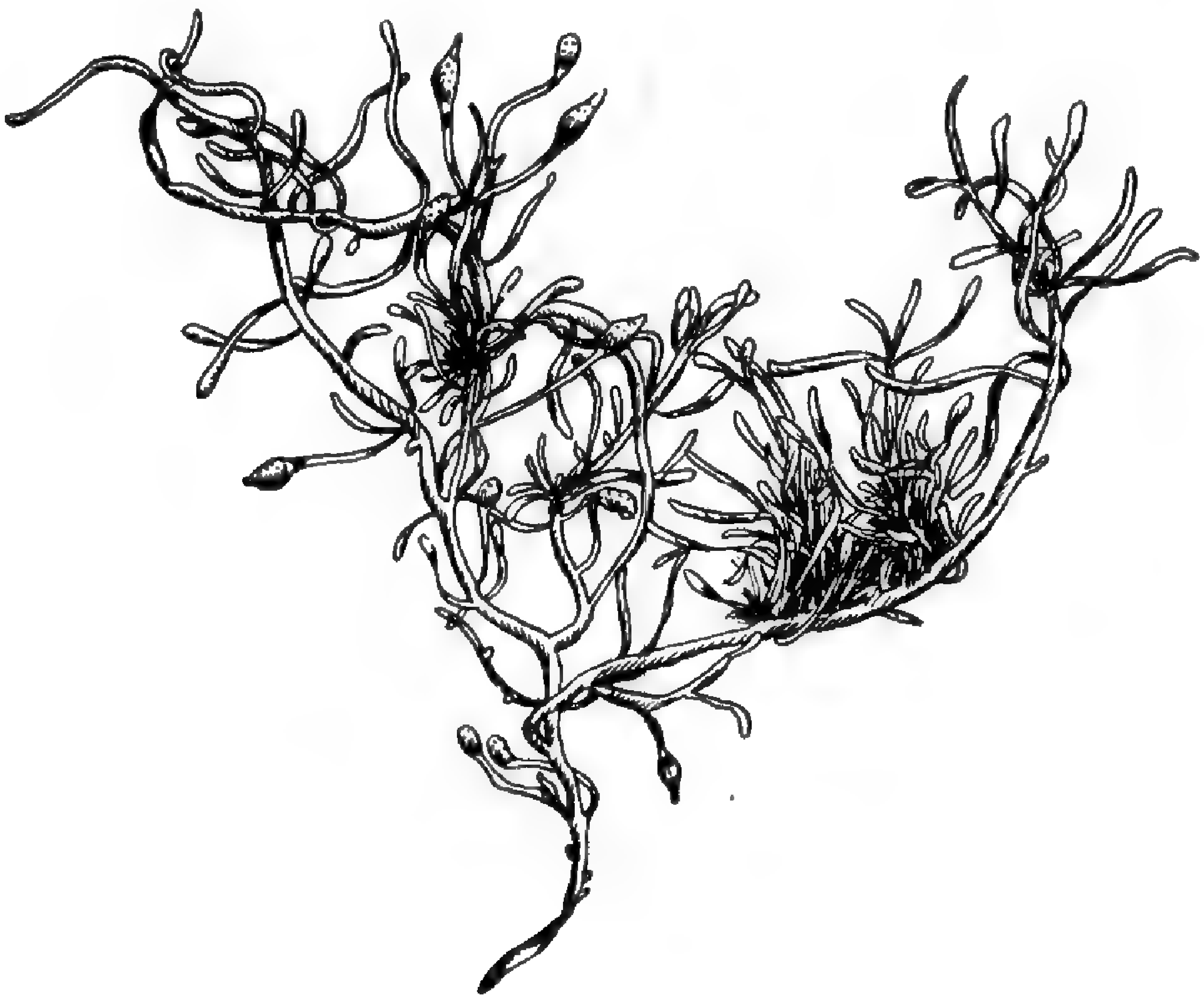


FIG. 1.—Plant of *Ascophyllum nodosum* v. [ecad] *scorpioides* showing receptacles borne on long straggling branches. Nat. size. The Ray Marshes, Essex, April 1912.

as to its status, for Reinke (1892, p. 11) and Oltmanns (1905, vol. ii. pp. 233 & 234) have described its origin by direct vegetative budding from fragments of typical *Ascophyllum nodosum*.

The loose-lying var. *Mackaii* has often been considered a distinct species on account of its pendulous receptacles, which are borne on long branches. But Cotton is undoubtedly correct in designating the plant as a variety of *A. nodosum*, induced by external conditions; for in the spring of 1912, and also 1913, we found the var. *scorpioides* fruiting in the Blackwater marshes (see fig. 1), and the receptacles are borne on long straggling branches,

intermediate between those of the var. *Mackaii* and the typical upright, short-stalked receptacles of *A. nodosum*. The reproductive organs of the var. *scorpioides*, like those of most other marsh Fucoids, are not functional, and the oogonia do not undergo any divisions.

The var. *minor* of *A. nodosum* is also found embedded in the marsh soil, though sometimes attached to pebbles below, in the Hurst Castle salt marshes, Hants (see Cotton in Morris, 1914, p. 192). It does not, at present, show the morphological peculiarities associated with the salt-marsh varieties of this species; but is worth keeping under observation, as it may, in time, give rise to the var. *scorpioides*.

The Marsh Fuci.

(a) *The Marsh Representative of* Fucus spiralis, *L.*

The dwarf variety of *Fucus spiralis*, characteristic of exposed situations on a rocky coast, is frequently found, attached to the subsoil with a definite disc, on the mud cliffs or channel banks of marshes. It has been amply described and discussed by Börgesen (1909, p. 109) and Sauvageau (1908, pp. 91–97), and previously reported from the salt marsh by Cotton (1912, p. 82). It shows no peculiarities on the salt marsh, reproduction being normal, and the habit being identical with specimens from the rock preserved in the British Museum and Kew herbaria.

(b) *The Marsh Forms of* Fucus vesiculosus, *L.*

Under this heading we have to discuss all the other marsh *Fuci* which have been described from the British Isles. The range of form among them is enormous; but they all have in common:—(1) embedded or unattached habit; (2) reproduction by vegetative budding; (3) terminal position of receptacles, where present; (4) numerous and prominent cryptostomata, chiefly marginal in position.

The nomenclature is chaotic; but this seems to be largely due to the fact that systematists have ignored the ecological distribution of the forms. For this reason there has been a continual confusion between the series, occurring here and on the French coasts, upon salt marshes, and the parallel, but not identical, series which occurs in the loose-lying formations of the Baltic (see par. entitled "The Baltic Fuci," p. 338).

The first question is the parentage of the marsh *Fuci*, and, as specimens from different localities are never identical in habit, it was necessary to study the *Fuci* from as many marshes as possible.

1. *The Blackwater* Fuci.

In the marshes of the River Blackwater (shown in sketch-map, Pl. **30**), one of the original localities for the *Fucus volubilis* of Hudson, the *Fuci* are abundant and show a great range of form. We made a series of collections from these marshes, from which we found :—

(1) That the varieties could be arranged in a single series, leading by gradual transitions from short, narrow, turf-like forms, showing no spirality,

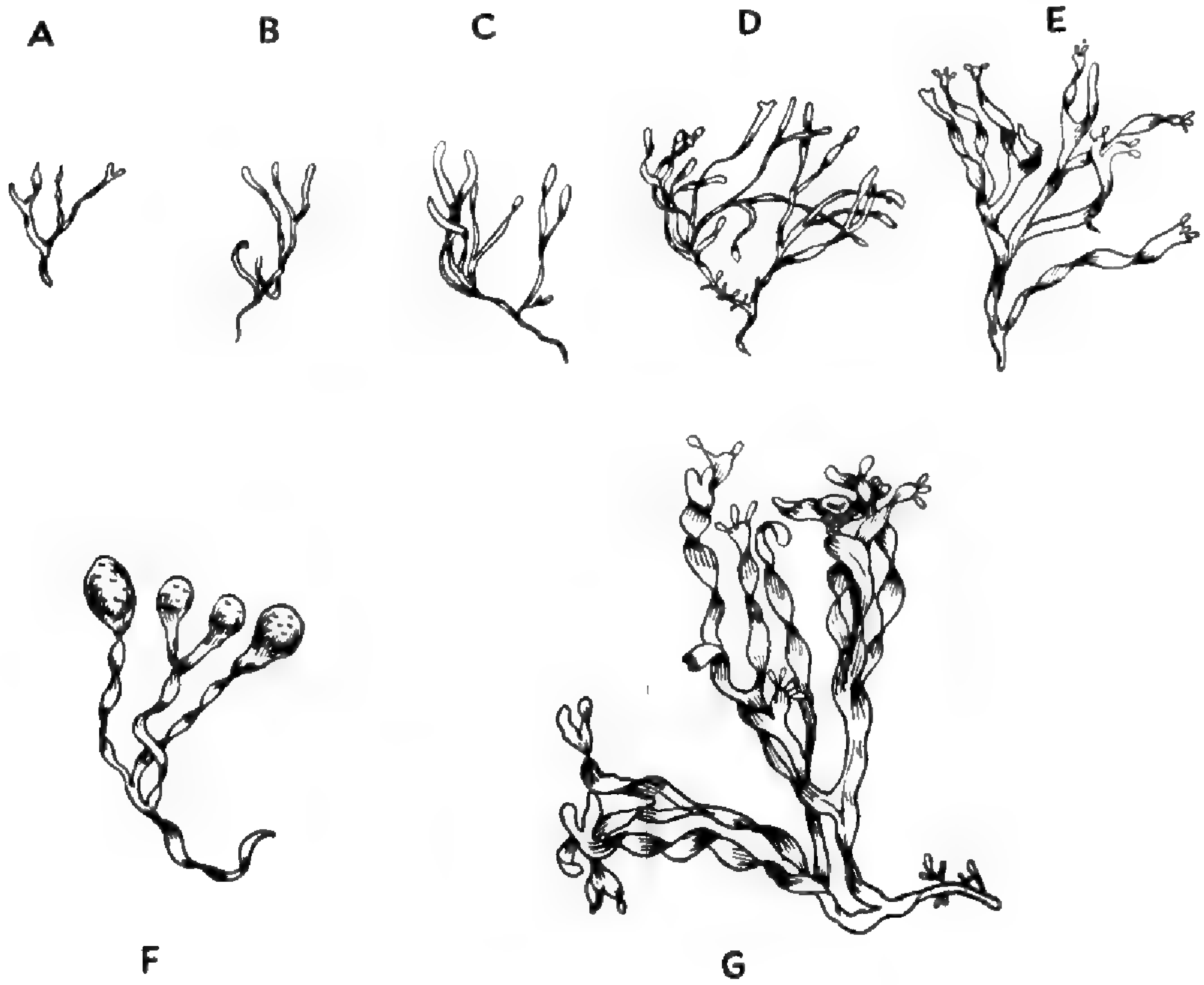


Fig. 2.—*Fucus vesiculosus* megecad *limicola*. Nat. size.

Showing transitions from the ecad *cæspitosus*, A, B, C, D, to the ecad *volubilis* (with one vesicle), G. F. Fruiting specimen. Blackwater Marshes, Essex.

to large forms with much spirality and the general habit of *Fucus vesiculosus*, L. (such a series is shown in text-figs. 2–6).

(2) That, in the intermediate forms, the presence or absence of vesicles is correlated with no change either in habit or distribution (see text-figs. 4–6).

(3) That the modifications in form could be directly correlated with the habitat in every case (see Part 2).

(4) That receptacles when present were diœcious, and these were found on all but the smallest varieties. Fig. 2, F, represents the smallest specimen found fruiting on these marshes.

For these reasons we inferred that all the Blackwater *Fuci* were derived from a single parent, *Fucus vesiculosus*.

2. *The Hurst Castle* Fuci.

The *Fucus* vegetation which accompanies *Spartina Townsendii* on the Hurst Castle marshes is very luxuriant and, in places, extensive. Plants of all sizes are found, forming a series similar to the Blackwater series (see Cotton in Morris, 1914, p. 192), in which many of the intermediates bear vesicles. In June 1914, one of us collected thirteen receptacles from the larger plants in this locality, and they were found to be all female, with undivided oospheres and nonprojecting paraphyses. The Hurst Castle *Fuci*

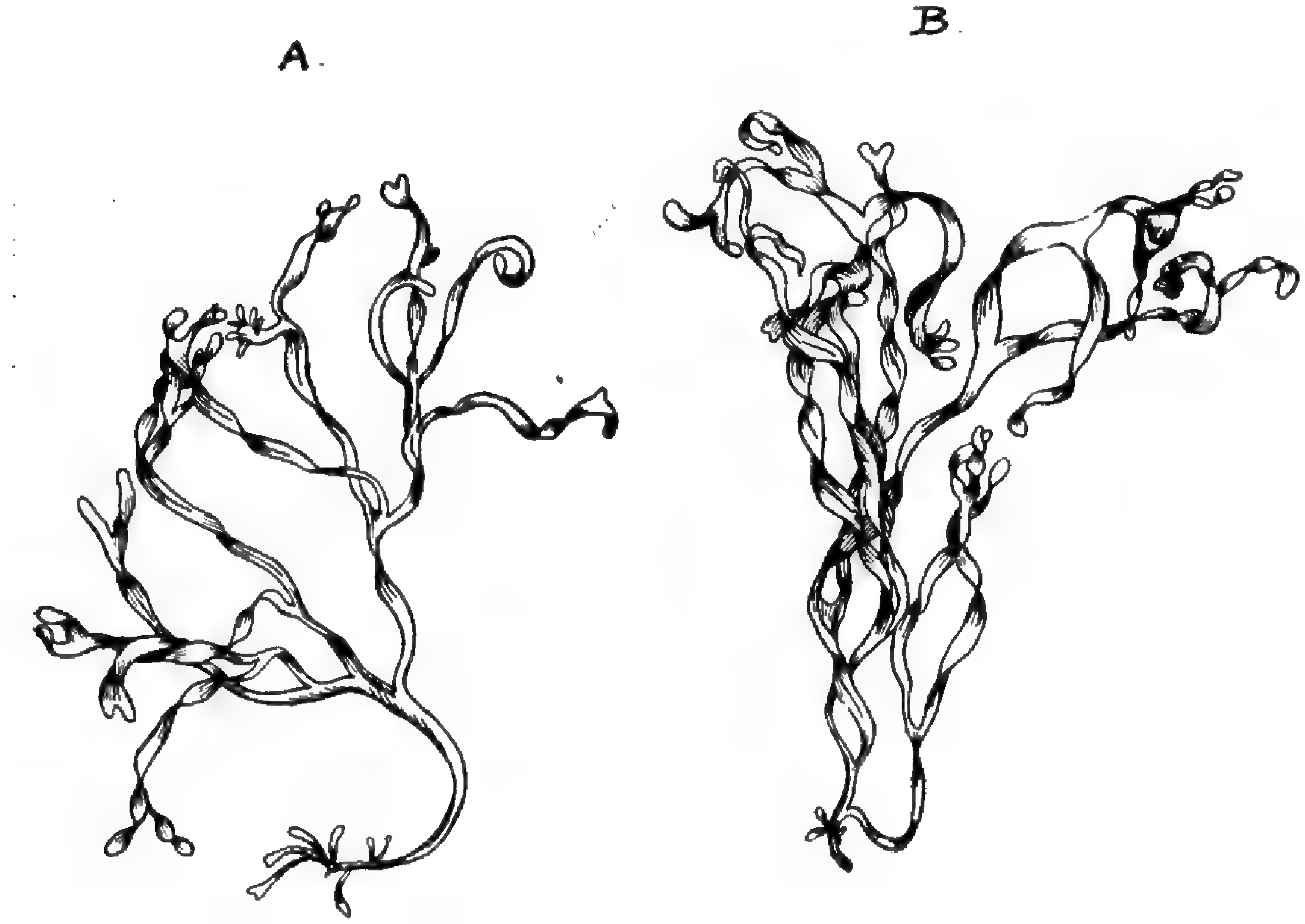


FIG. 3.—*Fucus vesiculosus* megecad *limicola* ecad *volubilis*. Nat. size. Intermediate form. A, without vesicles: B, with vesicle. Blackwater Marshes, Essex.

are analogous in habit to the Blackwater *Fuci*, but their branching is more luxuriant and fastigiate. On account of their monœcious receptacles and the frequent presence of vesicles, they are also referable to *Fucus vesiculosus*, L.

3. *The Blakeney* Fuci.

At Blakeney there are two distinct forms of *Fucus*, with no intermediates. The larger is spirally twisted and occurs with *Aster Tripolium*, L., on the lower levels of the marsh; it is referable, morphologically, to the intermediate forms of the Blackwater series, except that its receptacles are pointed and commonly filled with air, instead of ovoid and mucilaginous. But it is a peculiarity of the Blakeney area that no plant has yet been found bearing the characteristic vesicles quite common in plants of a similar habit in the Blackwater series. The same applies to the *Fucus* found by Turner (1802,

vol. i. p. 127) in 1792 in the Wells Marshes, Norfolk. Very occasionally at Blakeney, plants are found showing irregular swellings. Similarly, swellings (see fig. 7) occur on the Blackwater forms, sometimes associated with characteristic vesicles. However, the absence of vesicles is not decisive. A large number of receptacles have been examined and, of these, all except two have been strictly diœcious, the sexes being of about equal

Fig. 4.—*Fucus vesiculosus* megecad *limicola* ecad *volubilis*. Nat. size. Intermediate form with vesicles. Blackwater Marshes, Essex.

frequency. These two exceptional receptacles were borne on plants otherwise apparently normal. One of them showed a few hermaphrodite conceptacles in the upper part of a male receptacle ; the other bore female conceptacles above and male below. Their occurrence does not vitiate the main contention that the Blakeney plants are also diœcious and therefore referable to *Fucus vesiculosus*. They are probably reversions to a very ancient and primitive hermaphrodite habit in this alga, comparable to the reversions occasionally found in the rock species.

The small form grows in hummocks with *Salicornia europæa* in the *Pelvetia* zone. It is very close to the smallest Blackwater *Fuci* in habit, and it also approximates to the larger marsh *Fucus*, found by Cotton in Ireland. Although it has not been found fruiting, and bears no vesicles, it may be referred to the same species as these forms, namely, *Fucus vesiculosus*, L.

4. *The Clew Bay* Fuci.

Cotton, in his 'Report on the Clare Island Survey' (p. 125 & Pl. 6), gives an interesting account of the two *Fuci* found by him, covering large areas

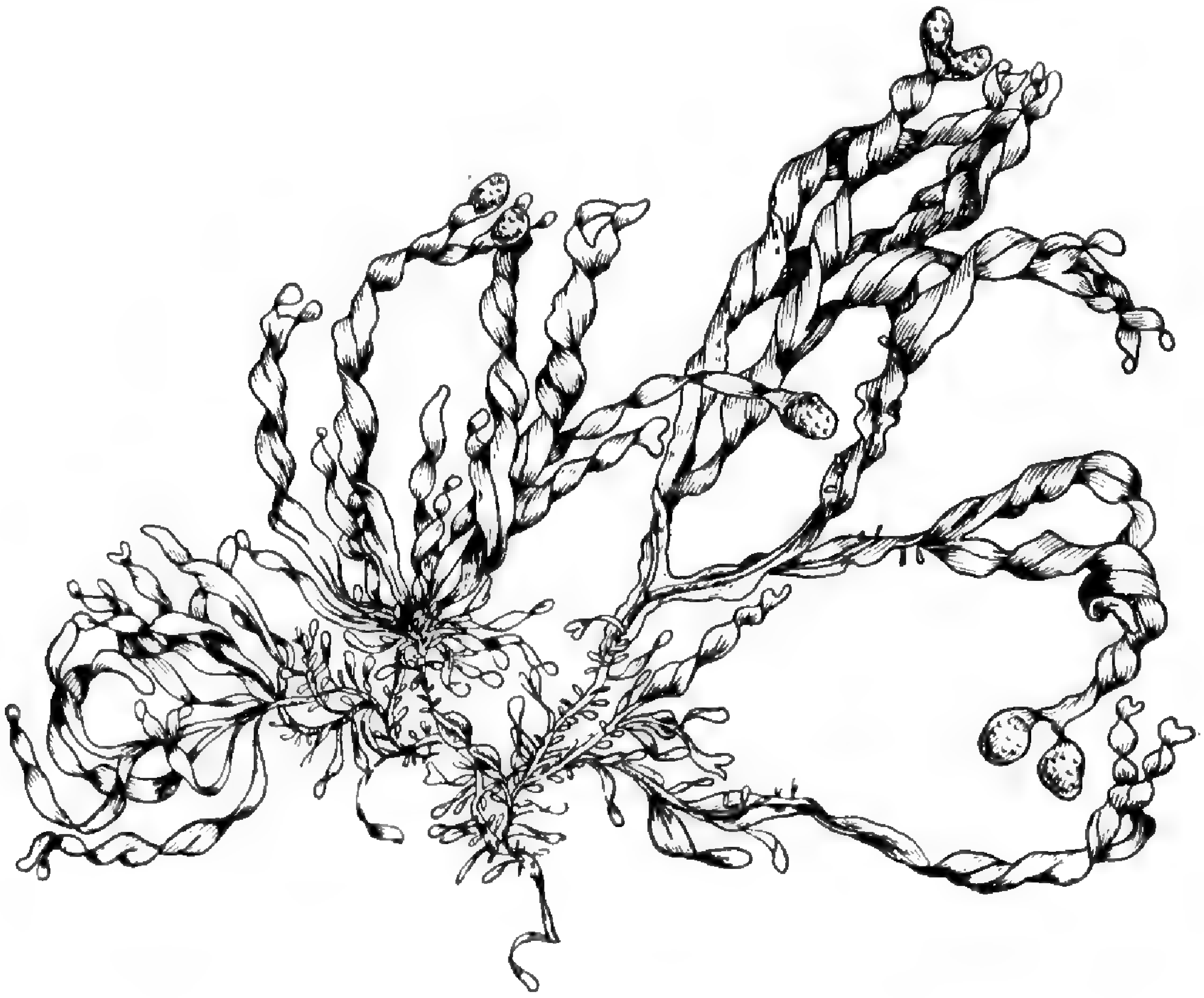


FIG. 5.—*Fucus vesiculosus* megecad *limicola* ecad *volubilis*. Nat. size.
Intermediate form showing receptacles and extensive vegetative budding, without vesicles. Blackwater Marshes.

of the peat marshes. He calls them *F. vesiculosus* var. *balticus*, and *F. vesiculosus* var. *muscoides*, respectively. Both are very dwarf forms, showing practically no twisting of the thallus; but numerous and prominent marginal cryptostomata. Neither bears vesicles. The most striking fact about them is that both forms, in spite of the minute size of the var. *muscoides*, occasionally bear receptacles which are perfectly developed in miniature, and these receptacles are found to be diœcious, both male and female plants having been collected. The var. *muscoides* is connected by intermediates with the var. *balticus*; which itself approaches very closely to the form of the smallest

Blackwater *Fucus*, though they are not identical, the Clew Bay plant being more richly branched, slightly tougher, and of a more reddish-brown colour than the Blackwater plant.

The evidence, however, points strongly to the inclusion of these dwarf varieties also under *Fucus vesiculosus*.

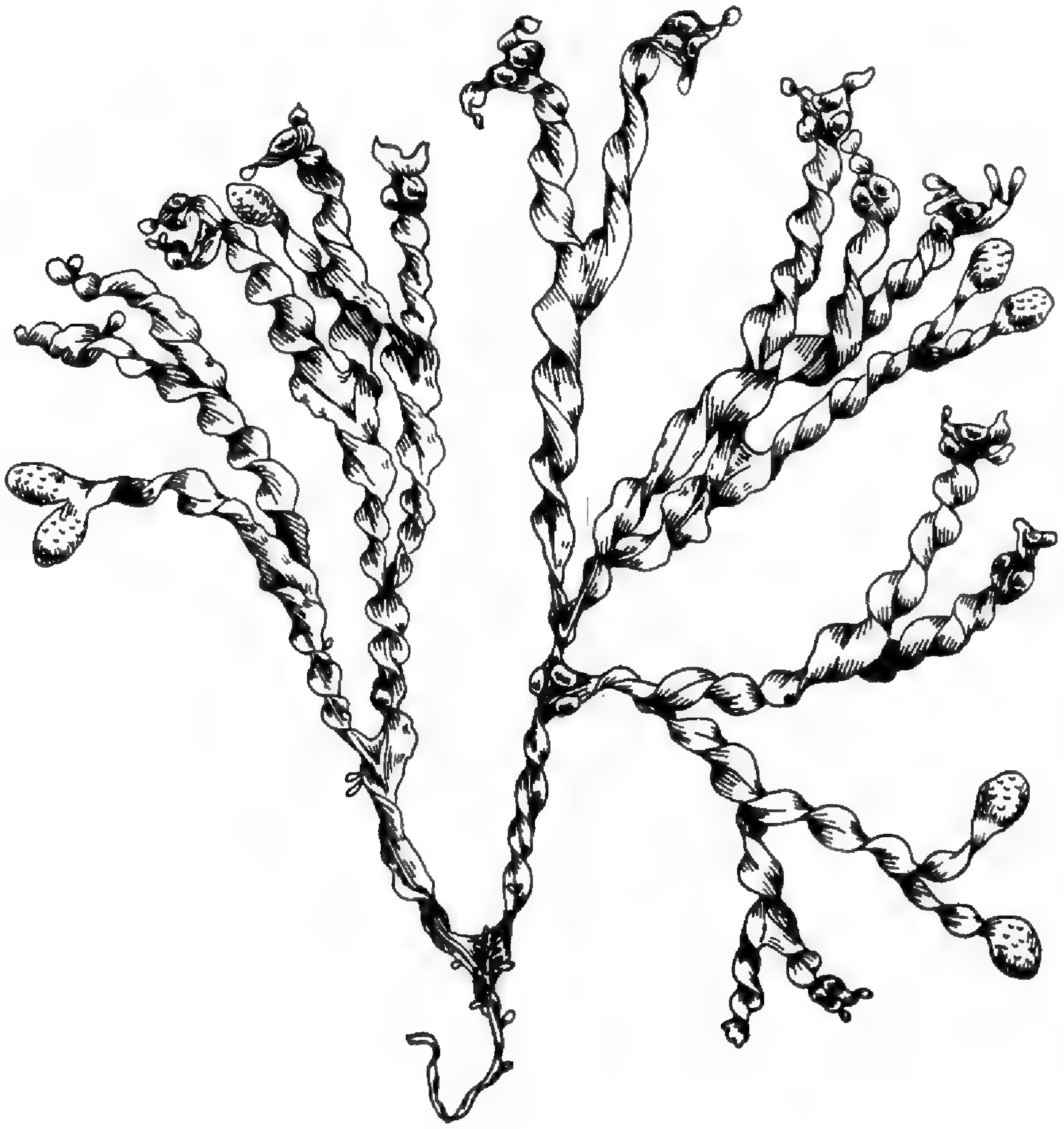


FIG. 6.—*Fucus vesiculosus* megecad *limicola* ecad *volubilis*. $\frac{1}{3}$ nat. size. Large form with vesicles and receptacles. Ray Marshes, Blackwater, Essex.

The British Marsh Fuci *in general.*

These four localities may be taken as fairly typical of the *Fucus* vegetation of British salt marshes. The most common form under which the *Fucus* appears is the small turf-like form known as *F. balticus*, Ag., or sometimes described as *F. vesiculosus* v. *subecostata*, after Harvey. This occurs in many marshes, as, for example, in the marshes behind Mochras in Carnarvon, or in the marshes of the Aln, Northumberland, as an undergrowth with a short turf of *Glyceria*, *Armeria*, etc. The specimens in the herbaria at Kew and the British Museum, from different parts of the country, approach in

form either to the smallest Blackwater *Fuci* or to the Clew Bay *Fucus*, or lie intermediately between them; and there can be little doubt that they are all varieties of the same plant. References to the literature will be found with the diagnoses on p. 353.

According to these data, all the English *Fuci* which have hitherto been described from salt marshes, except the very distinct *F. spiralis* v. *nana*, seem to be derived from *F. vesiculosus* rather than from *F. spiralis*. The

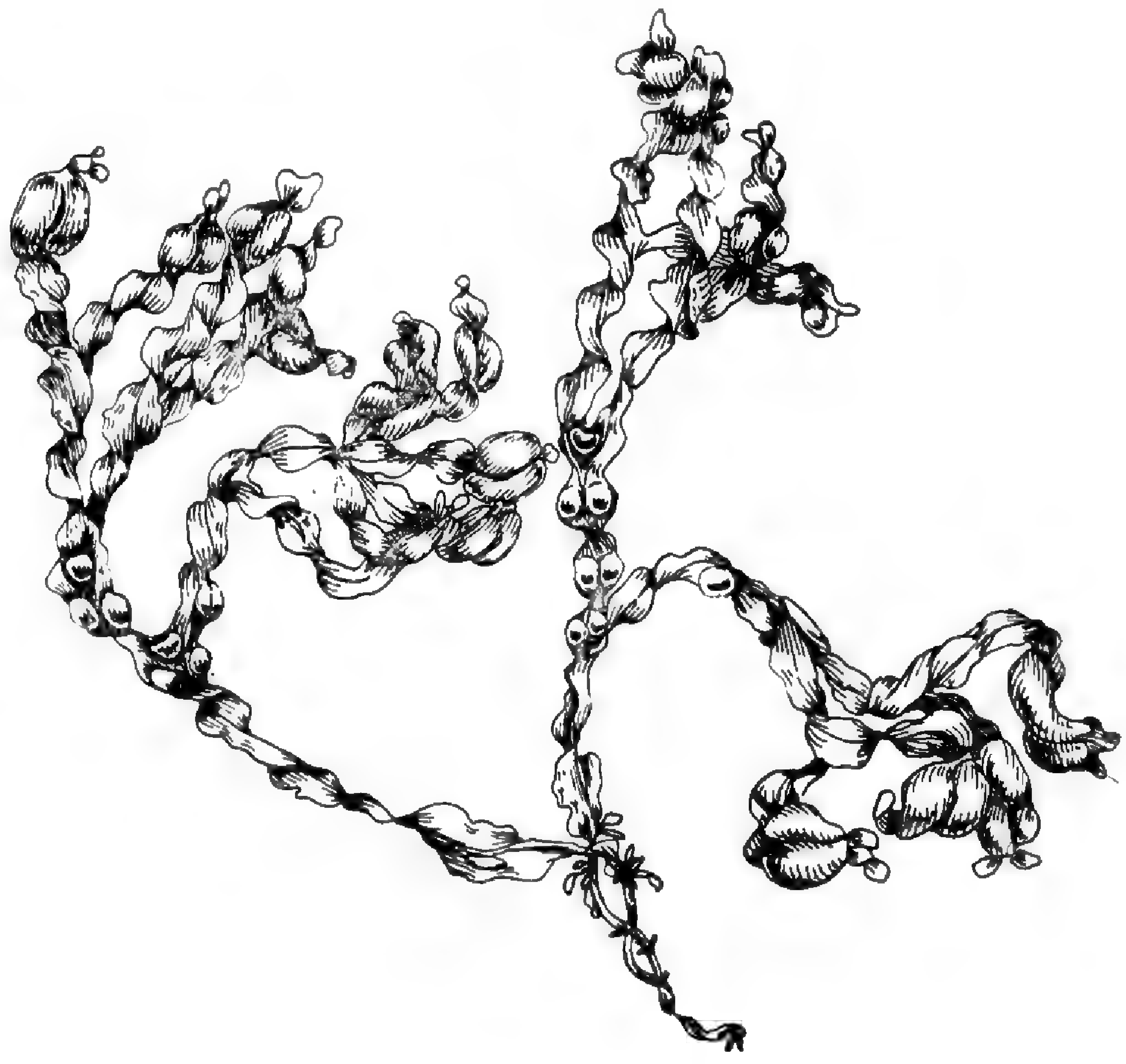


FIG. 7.—*Fucus vesiculosus* megecad *limicola* ecad *volubilis*. $\frac{1}{3}$ nat. size.
Large form with vesicles and irregular bladderlike swellings.
Virley Channel, Blackwater, Essex.

one remaining possibility was that *F. ceranoides* might have been responsible for the parentage of some of the non-vesicled forms. This has now been ruled out of court by the appearance of an undoubted marsh variety of *F. ceranoides*, which will be described in due course, and which is quite distinct from all these forms (p. 340). These marsh *Fuci* form one continuous series; but for the sake of convenience they will be divided into three groups: the large spiral forms into the *volubilis* group, the turf-like forms, known generally as "*Fucus balticus*," into the *cæspitosus* group, and the filiform forms into the *muscoides* group—all being varieties of *F. vesiculosus*, L. A further discussion of the nomenclature follows on p. 346.

The Marsh Fuci *of France and Spain.*

There still remains the question of the continental *Fuci*. Sauvageau (1908) has published an exceedingly valuable and elaborate study of two marsh *Fuci*, which he refers to *F. lutarius*, Kütz. The first of these two *Fuci*, the type *F. lutarius*, is morphologically identical with the medium-sized Blackwater forms, growing in rather dilute sea-water; but Sauvageau considers them as a distinct species, having affinities rather with *F. spiralis*, or with his recently described new species the hermaphrodite *F. dichotomus* (Sauvageau, 1915, p. 14), than with *F. vesiculosus*. This is for two reasons: first, because the *Fucus* never bears vesicles in that locality; and, secondly, because the receptacles are always female, and hence possibly reduced from hermaphrodite receptacles.

The second argument is obviously the more important; but it rests upon an assumption, which does not seem to be warranted by experience, the assumption that marsh conditions would tend to reduce a hermaphrodite conceptacle to a female one. There are certain hermaphrodite Fucoids which occasionally fruit upon the salt marsh:—*Pelvetia canaliculata* v. *libera*, *F. spiralis* v. *nana*, and lastly, *F. ceranoides*.

In every case the marsh form produces hermaphrodite, not female receptacles. In *Pelvetia* and *F. spiralis* they are normal, but in *F. ceranoides* we get the interesting evidence that marsh conditions have interfered with the normal reproductive economy of the plant, but with reduction of both the male and female constituents of the hermaphrodite plant, in different individuals. There seems, in none of these cases, to be any tendency for the survival of the female element of the hermaphrodite individual rather than the male.

For these reasons we consider *F. lutarius* as monœcious and probably referable to *F. vesiculosus*, together with the plant bearing vesicles, reported by Sauvageau from St. Vicomte de la Barquera in Spain. The variety *arcassonensis* of *F. lutarius* has much resemblance to the *F. balticus* from Clew Bay, already referred to *F. vesiculosus*, although it is considerably broader and larger in form, and the underground attachment by a bunch of rhizoids is unique. Probably it is to be grouped among the small turf-like marsh forms of *F. vesiculosus*; but without fertile plants or definite intermediate forms it is impossible to judge certainly.

American Salt-Marsh Fuci.

Certain *Fuci* from American salt marshes have been distributed by Collins in the 'Phycotheca Boreali-Americana.' Of these, the *F. vesiculosus*, v. *spiralis*, Farlow, which occurs with *Spartina* in muddy salt marshes (Johnson & York, 1915), is identical with an ordinary spiral v. *volubilis* of *F. vesiculosus*, such as is found at Hurst Castle with *Spartina*. The other

form, however, *F. vesiculosus* v. *limicola*, Collins, is quite distinct from anything we have seen in England. It is far less spiral than any marsh *Fucus* of that size on our shores, and it approaches *F. vesiculosus* v. *angustifolia* in habit. As it is diœcious it may possibly be another marsh form of *F. vesiculosus*, not connected with our series, but produced by special conditions in the American marshes. These *Fuci* would probably repay study.

The Baltic Fuci.

For more than half a century the dwarf *Fuci* of our salt marshes have been referred to the varieties of dwarf *Fucus* established by Swedish algologists, which occur in the Baltic Sea. The original *F. balticus* of C. Agardh, figured in 'Svensk Botanik' (fig. 516), although its habit is that of the *F. balticus* of Kützing and of Gobi in the vegetative condition, is shown (fig. 516 *e*, *f*, & *g*) with "fruit-bodies" (fruktknölar) quite unlike those of a *Fucus* and reminiscent of *Gracilaria* or *Sphærococcus*. Agardh certainly remarks that he has not found "seeds" (frön) produced inside these curious knobs, and it is possible that they are small groups of vegetative buds, not uncommon on the margins and at the summits of shoots in the dwarf *Fuci*. But, on account of the "fruit bodies," we have followed Svedelius in rejecting Agardh's description of the Baltic *Fucus*.

Kützing figures two specimens of *F. balticus*. One of these indicates a small form with an attachment disc and the shadowy fructifications of a *Fucus* reminiscent of a minute form of the v. *angustifolia* of *F. vesiculosus*: the other is a sterile plant, which Svedelius apparently accepts as *F. balticus*. Subsequent authors agree in describing the Baltic *Fucus* as always sterile. This plant has appeared under several names: *Fucus balticus*, a general term; and the three cognate varieties of *F. vesiculosus*, the forms *nana*, *subecostata*, and *filiformis*. These names have been applied by English systematists to our small salt-marsh *Fucus*; the name *balticus*, either as a separate species or as a variety of *F. vesiculosus* by Greville, Hooker, and Batters, and the name *subecostata* by Harvey and Greville, the former without reference to a previous use of the same name.

It is therefore imperative to find out the exact relationships between our marsh *Fucus* and the Baltic *Fucus*. A most interesting account of the various forms of *Fucus* found on the Baltic coast, together with a description of the remarkable ecological formation which they dominate, has been given by Svedelius (1901, pp. 34–38 & 84–92). As his paper is not very generally accessible, we have summarized those of his results which have a direct bearing upon the question.

The Loose-lying Algal Formations of the Baltic.

The dwarf *Fuci* of the Baltic, included by the older writers under the general name of *Fucus balticus*, all belong to the "Loose-lying" formation of

Kolderup-Rosenvinge (1898, p. 218), which is analogous to the "Migrations-formation" described by Schiller (1909, pp. 62–98) from the Adriatic Sea.

All the loose-lying formations occur within the sublittoral region. They are composed of different forms derived from the attached species of the littoral region, which, when torn loose by the waves and carried by the currents into still places, collect together in great masses on the floor of the sea. Here they continue to grow, reproducing themselves by vegetative means, often over a mobile bottom, otherwise destitute of vegetation; but they never become embedded or fixed to the substratum.

The dwarf *Fuci* are dominant forms in the uppermost of the two chief loose-lying formations of the Baltic; the formation characteristic of deeper waters is dominated by *Phyllophora Brodiaei* f. *elongata*. The loose-lying *Fucus* formation occurs, in general, at a little depth, varying from 8–10 metres; but occasionally the formation may extend up to the lower limits of the littoral zone.

The Loose-lying Fuci.

The loose-lying *Fuci* are uniformly sterile, but Svedelius was able to collect a number of intermediate forms, which led up to well-established and fertile attached varieties of *F. vesiculosus*. He separates three distinct series of loose-lying *Fuci*, naming them, according to J. G. Agardh's system, f. *nana*, f. *subecostata*, and f. *filiformis* of *Fucus vesiculosus*.

The f. *nana* series is characterised by folds and curves in the margins of the thallus and cryptostomata, which are very indistinct and scattered, or else wholly absent. This series leads by intermediates to *F. vesiculosus* v. *plicata*, Kjellm. Arcichovskij (1905) figures a detached specimen of *F. vesiculosus* (p. 28, fig. 9) in which the old parts had weathered away to the midrib and new shoots had arisen at the tip with the habit of the form *nana* but bearing minute male receptacles.

The f. *subecostata* series is characterised by prominent cryptostomata arranged in two rows, one on either side of the midrib in the larger forms, and marginally in the smaller forms. This series leads through intermediates to *F. vesiculosus* f. *angustifolia*, C. A. Ag.

The f. *filiformis* series is characterised primarily by complete absence of cryptostomata, many of the larger forms are otherwise identical with the *subecostata* series; but the smallest forms reach filiform dimensions. These forms again lead up to *F. vesiculosus* v. *angustifolia*.

Arcichovskij (1905, p. 136) has further subdivided these three series, but as his distinctions depend mainly upon the system of branching, which is always highly variable in the dwarf *Fuci*, they seem to rank rather as subdivisions of these groups than as distinct forms.

It will be seen that we have here a complicated series of forms which are in many ways parallel to the small *Fuci* of our salt marshes and derived from the same species, *F. vesiculosus*, but which are undoubtedly not identical with

them. In the first place, our marsh *Fuci* form a single series, in which the larger forms are very much spirally twisted, and the tendency to spirality is shown in all but the smallest varieties. This spirality is absent from the larger forms of all three Baltic series. Secondly, marginal cryptostomata are a prominent feature of all the forms of our series, including the filiform v. *muscoides*, which is otherwise very similar to the Baltic f. *filiformis*. The nearest approach to our series is shown by the smallest of the f. *subecostata* series; but the Baltic forms are at once distinguishable, first, by the radially arranged, very fastigiate branching, due, no doubt, to their unattached habit, and, secondly, by the considerably tougher consistency of their thallus. The comparatively thick thallus with evident notches, in the margins, for the insertion of cryptostomata, is well shown in Gobi's figures and also, according to Sauvageau (1912, p. 146), in his herbarium specimens. In his description he mentions absence of cryptostomata as a feature of his plants, so that, apparently, he was dealing with mixed forms. Both the radial branching and coarse texture are very evident in Areschoug's specimen of *Fucus balticus* in the Algæ Scand. No. 85, at Kew. We have also been able, by the great courtesy of Prof. Svedelius who sent us some specimens from his own collections, to compare specimens of the smallest *subecostata* and *filiformis* types from the Baltic with our own *Fuci*.

It is evident that the name *Fucus balticus*, which was originally bestowed upon the Baltic forms, is not applicable to any of the British salt-marsh *Fuci*, and the retention of that name can only lead to confusion. On the other hand, the name *subecostata*, which belongs by right of Harvey and Greville's authority to our English *Fucus* (and definitely, according to Harvey's account, to a salt-marsh form), has become attached, by C. Agardh, J. G. Agardh, and Svedelius, to one of the Baltic forms, and it would only cause more confusion to reshuffle the names. Moreover, except for a suggestion from Sauvageau (1912, p. 147), whose illuminating account of the continental herbarium material of *Fucus balticus* has been of very great assistance to us, no author has attempted to separate the marsh forms of these coasts from the loose-lying Baltic forms.

Hence we venture to suggest a new name for the small marsh form, commonly called *Fucus balticus*. As its chief characteristic is a turf-like habit, we suggest the name *Fucus vesiculosus* v. *cæspitosus*, retaining the names of v. *volubilis*, Huds. and v. *muscoides*, Cotton, for the largest and smallest representatives of our series. Further suggestions as to the nomenclature of marsh forms in general are more conveniently reserved to a later paragraph (see p. 346).

(c) *The Marsh Form of* Fucus ceranoides, *L.*

Behind Keyhaven, Hants, there is a reclaimed marsh irrigated by a channel of fresh water and shut off from the Hurst Castle salt marshes by

FIG. 8.—*Fucus ceranoides*, L., attached to rhizomes of *Triglochin maritimum*. $\frac{1}{3}$ nat. size. Brackish marshes, Keyhaven, Hants.

means of sluice-gates. The gates do not prevent a considerable influx of salt water at high-tide, so that these reclaimed marshes have the character of brackish-water marshes, the chief vegetation being :—

Scirpus maritimus. *Scirpus palustris.*
Triglochin maritimum. *Heleocharis palustris.*
Arundo Phragmites.

The normal attached *Fucus ceranoides* was abundant around the sea-walls and groins near to the sluice-gates; but on the marsh itself the same *Fucus* formed a dense undergrowth among the rushes, similar in appearance to the

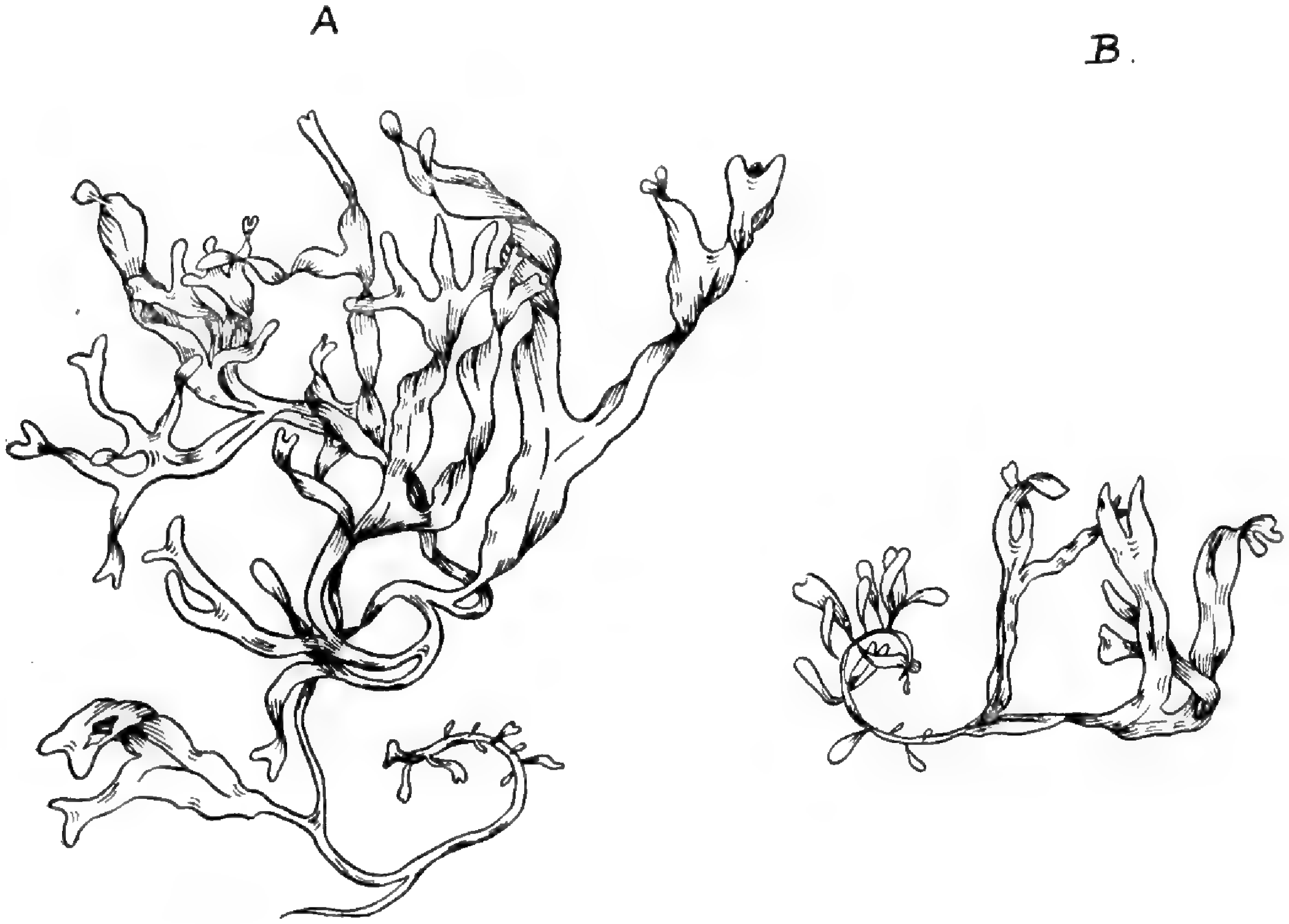


FIG. 9.—*Fucus ceranoides* megecad *limicola*. Nat. size.
Embedded with *Heleocharis*, lower zone: A, showing relics of attachment disc.
Keyhaven, Hants.

undergrowth of *Fucus vesiculosus* v. *volubilis* among *Spartina Townsendii* in the adjacent salt marshes.

On examination the undergrowth proved to be composed of two distinct forms. The first was attached to the rhizomes of the larger rushes, *Scirpus*, *Arundo*, etc., usually below the ground. Its habit was identical with a much curled rock *Fucus ceranoides*, producing numerous adventitious shoots from the lower parts of the thallus (see fig. 8).

The second form was a typical marsh variety. It was much dwarfed, only about half or a quarter the size of a normal plant, and grew embedded but unattached in the upper zones of the marsh with *Heleocharis*. The plants were much curled and interwoven, and vegetative budding was prevalent along the buried part of the thallus. In April this budding was so extensive that the habit of the parent plants was masked by it. The plant was at once distinguishable from *Fucus vesiculosus* v. *volubilis* by (*a*) the absence of marked spirality, (*b*) the great delicacy of the thallus, (*c*) the arrangement of the cryptostomata, which were never marginal, but were often arranged in two rows, one on either side of the midrib. The arrangement of the

FIG. 10.—*Fucus ceranoides* megecad *limicola*. Nat. size.
Embedded with *Heleocharis*, upper zone. Keyhaven, Hants.

receptacles was also on a miniature scale, the same as that of *Fucus ceranoides*, L.; tiny receptacles about the size of a hemp seed being arranged in lateral corymbs around a relatively broad central axis (see figs. 9, 10, & 11). Occasionally this form occurred loose among the *Scirpus*.

The Receptacles of the Marsh Fucus ceranoides.

The most interesting point about these marsh forms is their reproductive organs. The *Fucus ceranoides* found growing on sea-walls or embedded pebbles at Keyhaven was uniformly hermaphrodite, the oogonia were

developed and divided in the usual way, and in every case examined the proportion of the sexes in any one conceptacle was approximately equal. But in both the marsh forms described above, the reproductive organs were abnormal. On the dwarf embedded form they were very rare, but they were freely produced upon the attached form. In all cases, however, the oogonia, although occasionally reaching full size, were undivided, and there was, in addition to this, a great variability in the proportions of the two sexes in any one receptacle. On the same plant, and often in the same receptacle, all stages could be found, from a normal, equally divided, hermaphrodite conceptacle to one containing a great preponderance of antheridia, and,

FIG. 11.—*Fucus ceranoides* megecad *limicola*. Nat. size.

Embedded with *Heleocharis*, lower zone; plant showing receptacles. Keyhaven, Hants.

finally, to a pure male conceptacle. In the same way the transitions were shown, through a preponderatingly female conceptacle to a pure female one. This extraordinary variability is very interesting in view of the well-known property of *F. ceranoides* of forming either hermaphrodite or diœcious plants. It seems as though the new conditions incidental to the marsh habit had, in some way, upset the equilibrium of the reproductive mechanism of the plant; so that the hermaphrodite and the diœcious factors, whatever they may be, became mingled in irregular proportions throughout the organism. The reasons for these peculiarities in the marsh form of *F. ceranoides* will be discussed later.

Other Records of this Marsh Form.

Although the marsh form of *Fucus ceranoides* has not been recognised hitherto, there is a small specimen in the British Museum Herbarium which probably belongs to this dwarf form. It is labelled "J. Cocks, Algarum Fasciculi, 1855–60," and was originally named *F. ceranoides*; but below is written *F. vesiculosus?* It is 6 cms. high by 10 cms. across, and has neither attachment disc nor fruiting branches nor adventitious shoots. The description runs:—"A plant that grows in ditches, or places where freshwater streams are occasionally overflowed by the sea. Not very common."

Near Laira Lake, Plymouth, Torbay, and coast of Cornwall.

Although there is no evidence as to whether this plant was attached to stones or embedded in the mud of these ditches and streams, and it is difficult from a dried specimen of this antiquity to recognise the characteristic delicacy of the thallus, it seems very probable that this is a specimen of the dwarf embedded variety of *F. ceranoides*, similar to that found at Keyhaven. We have not had the opportunity of visiting the localities given to investigate the matter.

The Origin and Status of the Marsh Fucoids.

On British salt marshes, five out of the seven upper littoral rock species of the Fucoideæ are represented, and very probably the only reason for the absence of *Fucus serratus*, *Halidrys*, and *Cystoseira* is their extreme intolerance of desiccation. It is noteworthy that three species of *Cystoseira* occur in the loose-lying formations of the Adriatic Sea (Schiller, 1909, p. 72). It is quite possible that *Himanthalia* will be found on the salt marsh.

In their new habitat striking morphological peculiarities arise, which, in some cases, are so great that the marsh forms have been designated as distinct species. Where direct evidence is available, as in the case of *Ascophyllum nodosum* v. *scorpioides* (Reinke, 1892, p. 11, and Oltmanns, 1905, ii. p. 233), it points to the production of these curious forms by direct vegetative budding from detached portions of the thallus of normal plants. But this evidence is difficult to obtain upon salt marshes, because, once the ground has been infected, vegetative reproduction continues on a large scale from the marsh form itself, so that the extensive areas may be covered by the products of one individual. In certain cases, even the access of normal plants to the marsh may be only occasional. For example, the nearest station to the Blackwater marshes for *Ascophyllum nodosum*, the parent of the var. *scorpioides*, which is quite abundant there, is Burnham-on-Crouch—eight or ten miles south of the Blackwater—and the presence of *Ascophyllum* in the drift along the Blackwater is sporadic.

In the case of the dwarf *Fucus ceranoides*, apparently the original inoculation is by means of fertilised oogonia from the attached plants in the neighbourhood. These become fixed below to the roots or rhizomes of Phanerogams; but if the latter happen to be ephemeral, the anchorage is withdrawn after a season, and the *Fucus*, remaining embedded, continues to reproduce itself vegetatively, till, finally, all trace of attachment is lost. One dwarf plant of *F. ceranoides* was found which had a definite attachment disc, but was entirely unattached and embedded (fig. 9 A).

It seems probable that in other cases the marsh forms have arisen by one or other of these methods. Certain experiments were set up on the Samphire Marsh at Blakeney Point (for topography see Oliver, Journ. of Ecology, 1913, p. 13) to test the behaviour of detached fragments of *Fuci* under marsh conditions. A series of ten squares, one foot across, were carefully cleared of all algæ, and, in each, five pieces of the thallus of *Fucus vesiculosus* from selected rock-plants of characteristic habit, with vesicles and diœcious receptacles and showing no spirality, were pinned down, covered with netting, and marked. A similar series was made with *Fucus spiralis* plants. The plants were set out on August 20, 1913. On July 10, 1914, the area was again visited. The tide had evidently scoured the marsh considerably; but of the twenty groups of plantings, five groups of *F. spiralis* and three of *F. vesiculosus* were left.

All the specimens of *F. spiralis* showed normal fruiting and no vegetative sprouting. Only one of the *F. vesiculosus* specimens was fruiting, and all were sprouting vigorously from the midrib. Drawings of some of the specimens are shown in figs. 12 & 13 (pp. 359 & 360). They were removed from the planting because the area was being infected by the ordinary v. *volubilis* coming in with the tide, so that, if the disintegration of the original planted fragments were continued much longer, it would be impossible to identify the specimens. The experiments show that the rock *F. vesiculosus* does tend to sprout vegetatively from small fragments of the thallus which may become embedded in the marsh, and probably after one or two vegetative generations the characteristic marsh form would be produced. It is interesting that *F. spiralis*, under these conditions, continues its normal course undisturbed; this possibly explains why it produces no distinct variety. An experiment in which it was attempted to induce the marsh variety to recur to the habit of *F. vesiculosus*, by attaching it to a post in the channel, was not successful.

Proposed Nomenclature.

In view of this probable mode of origin of the marsh varieties, we do not consider that any of them merit the rank of distinct species. They are rather to be regarded as "ecads," a name proposed by Clements (1905, p. 148) to

indicate a new form which results from adaptation or a change in morphology due to a new habitat. Each of these marsh varieties is, then, an ecad. But there are certain definite modifications in habit, correlated with the marsh habitat, which distinguish all the marsh ecads very sharply from the numerous morphological varieties which have been recognised in the rock species, and these modifications are not only maintained through many vegetative generations but are common to all the species which inhabit salt marshes.

For this reason we propose to group together all the salt-marsh ecads into one "megecad" which will define the general peculiarities due to the habitat. We shall call this the megecad "*limicola*," including in the term all the mud-dwelling Fucoids as distinguished from their saxicolous parents. This megecad *limicola* comprises two sections, the varieties of the salt-marsh formation and the varieties of the loose-lying formation, both of which, as we shall see later, are dominated by very similar physical conditions.

The general characteristics distinguishing the megecad *limicola* for the Fucoideæ are :—

(1) Vegetative reproduction.
(2) Absence of a definite attachment disc.
(3) Dwarf habit.

And, applicable to the salt-marsh section only :—

(4) Curling or spirality of the thallus.

At least three of these characters should be present to justify the inclusion of a variety under the "megecad" *limicola*. As was before stated, *Fucus spiralis* v. *nana* and *Ascophyllum nodosum* v. *minor*, although they occur on marshes, cannot be considered as true marsh forms, but are practically identical with the corresponding saxicolous varieties.

The following Table has been drawn up to summarize the results brought forward in this section. For the sake of comparison, the loose-lying forms of *F. vesiculosus* and also the form of *F. inflatus*, signalised by Rosenvinge and later by Jønssen as forming a dense matted growth of twisted fronds in lagoons of calm water in Greenland, have been included, although the species are not British. The tabulated descriptions apply always to the mud forms and not the parent species.

Table showing Relationships between Rock and Mud Species.

Rock Species.	Mud Form.	Habit.	Attachment.	Reproduction.
Pelvetia canaliculata.	Megecad *limicola.*			
	ecad *radicans.*	Dwarf.	Embedded & rhizoids.	Vegetative.
	ecad *coralloides.*	Dwarf, coralline.	Embedded.	Vegetative.
	ecad *libera.*	Curled.	Free.	Vegetative.
Fucus spiralis.	var. *nana.*	Dwarf.	Disc or rhizoids.	Normal.
Ascophyllum nodosum.	var. *minor.*	Dwarf.	Embedded.	Normal.
	Megecad *limicola.*			
	ecad *scorpioides.*	Dwarf, curled.	Embedded or free.	Vegetative.
	ecad *Mackaii.*	Dwarf.	Free.	Normal.
Fucus vesiculosus.	Megecad *limicola.*			
	Marsh Section.	*Crypts marginal.*		
	ecad *volubilis.*	Spiral, gen. dwarf.	Embedded.	Vegetative.
	ecad *cæspitosus.*	Dwarf.	Embedded.	Vegetative.
	ecad *muscoides.*	Very dwarf.	Embedded.	Vegetative.
	Loose-lying Section.	*Crypts variable.*		
	ecad *nanus.*	Dwarf, flexuous.	Free.	Vegetative.
	ecad *subecostatus.*	Dwarf, crypts marginal.	Free.	Vegetative.
	ecad *filiformis.*	Very dwarf, crypts absent.	Free.	Vegetative.
Fucus ceranoides.	Megecad *limicola.*	Dwarf and curled.	Embedded or free.	Vegetative.
Fucus inflatus.	Megecad *limicola.* ecad *membranaceus.*	Dwarf and curled.	Free.	Normal or vegetative.

For the sake of convenience a uniform series of diagnoses has been drawn up to include the British salt-marsh forms, as well as the loose-lying forms. The specific diagnoses are from Rabenhorst's 'Kryptogamen-Flora von Deutschland,' or Harvey's 'Phycologia Britannica,' with slight modifications, where references to the literature on each species will be found.

DIAGNOSES.

PELVETIA CANALICULATA (L.); Decne. & Thur.

Frond linear, narrow, channelled on one side, without midrib or air-vesicles, dichotomous, 5–20 cms. in length, 2–3 mm. broad; attached by disc. Receptacles terminal, bipartite. Hermaphrodite. The oogonium produces two oospores.

Megecad LIMICOLA.

Plant unattached by disc, reproduction by vegetative budding. Receptacles rare or absent.

(*a*) Ecad *radicans*, Foslie.

Plant of 2–2·5 cms. in height, forming extensive and rather interwoven fastigiate patches. In ramification it coincides with the typical form of the species, but the lower part of the frond is somewhat creeping, provided with more or less numerous rhizoids, connecting the particular individuals to one another and penetrating about 1 cm. in the clay. Channelling of frond very indistinct.

Hab. Gregarious, in great numbers in shallow pools with clay at bottom, and probably brackish water; far from sea, but close to a brook called Ridelven, near Trondhjem, Norway. Now extinct.

Pelvetia canaliculata f. *radicans*, Foslie, New or Critical Norwegian Algæ, Trondhjem, 1894, p. 6, & pl. 1. fig. 2. Reprinted from M. Foslie, Algological Notices, K. Norske Vidensk. Selskabs Skrifter for 1891, Trondhjem, 1892, p. 263.

(*b*) Ecad *coralloides*, S. M. Baker.

Plant embedded in mud, from 1–4 cms. in length, producing adventitious buds from lower parts of thallus. Frond channelled, branching sparse, thallus somewhat curled. Receptacles unknown.

Hab. Sheltered salt marshes, Blakeney Point, Norfolk.

P. canaliculata v. *coralloides*, S. M. Baker, in Journ. Linn. Soc., Bot. xl. (1912) p. 289, fig. 4.

(*c*) Ecad *libera*, S. M. Baker.

Plant not attached in any way, from 10–15 cms. in length, producing numerous adventitious buds from various parts of the thallus. Frond possessing the characteristic channelled form of the species, profusely branched by dichotomy, the growing ends much curled away from the ground, dark brown or olive-green in colour. Receptacles rare, normal.

Hab. Among the higher plants, especially *Salicornia europæa*, of sheltered salt marshes, Blakeney Point and Burnham Overy, Norfolk.

P. canaliculata v. *libera*, S. M. Baker, in Journ. Linn. Soc., Bot. xl. (1912) p. 289, figs. 2 & 3; also see Oliver, 1913, p. 20.

ASCOPHYLLUM NODOSUM (L.); Le Jolis.

Thallus up to 1 metre and more in length, compressed, without midrib, with air-bladders in the central line at intervals, generally 5–10 mm. broad, showing both dichotomous and lateral branching; attached by a disc. Air-bladders oval or elongated, broader than the thallus. Fruit-bodies

egg-shaped or oval, produced at the top of short, narrow, lateral branchlets, which arise in the axils of indentations in the thallus and fall away later. The oogonium divides into four oospheres. Diœcious.

Var. MINOR, Turner.

Thallus 10–20 cms. long, tufted from the base. Frond ovate, hardly broader than the peduncle. Air-bladders scarce.

Hab. Attached to rock high on shore, or embedded in salt marsh. Coast of Hants, Portsmouth.

Fucus nodosus β. minor, Turner, British Fuci, p. 253.

Ascophyllum nodosum v. *minor*, Batters, in Journ. Bot. xl. (1902) Appendix, p. 50.

Megecad LIMICOLA.

Plant unattached by disc, dwarf, irregularly curled and twisted. Receptacles on long drooping branches. Reproduction vegetative.

(*a*) Ecad *scorpioides*, Hauck.

Thallus almost cylindrical, 20–30 cms. in length, laterally branched. Branches elongated, narrow. Air-bladders absent. Receptacles rare, spherical or ovoid, 1–2 mm. in diameter, on long drooping branches.

Hab. (*a*) Lower parts of thallus embedded in mud of salt marshes and the estuaries of rivers, from the Tweed to Dover. Roundstone Bay, Ireland; Hunter's Island, New York.

(*b*) Lying loose on the sea-bottom in sheltered lagoons. Cattegat and western shores of the Baltic.

Fucus scorpioides, Hornem. in Fl. Dan. tab. 1479.

Fucodium nodosus var. *γ. scorpioides*, J. Ag. Spec. Alg. i. p. 207.

Fucus nodosus var. *β. denudatus*, C. A. Ag. Spec. Alg. p. 86.

Ozothalia vulgaris scorpioides, Kütz. Tab. Phyc. x. p. 8, Taf. 20. fig. *γ*.

Ascophyllum nodosum v. *scorpioides*, Rabenhorst, Krypt.-Flora v. Deutsch. ii. p. 289, fig. 120 *c*; Oltmanns, Morphologie u. Biol. d. Algen, ii. p. 234, fig. 530; Beiträge zur Kenntniss der Fucaceen, T. 8 and pp. 41–43; Reinke, Algenflora der Westlichen Ostsees, p. 34.

(*b*) Ecad *Mackaii*, Turner.

Fronds growing in globular tufts 15–20 cms. in diameter, many radiating from a subcentral point, but without obvious root or attachment. Frond cylindrical or subcompressed, slender, much branched. Branches dichotomous. Air-vessels elliptical, solitary, 0·5–1 cm. in length, 0·2 cm. wide, few, occurring generally below the forkings of the longer branches, sometimes wanting. Receptacles lateral, lanceolate, ovate or forked, stalked, pendulous, scattered, near the base of the branches.

Hab. Muddy or sandy seashores, usually in land-locked bays and among

boulders. Coasts of Scotland: Shetland Is. to Solway Firth; Ireland: Roundstone Bay. Baltic Sea. Connecticut.

Ascophyllum nodosum v. *Mackaii*, Cotton, in Proc. Roy. Irish Acad. xxxi. (1912) pp. 128, 129.

Fucus nodosus v. *Mackaii*, C. A. Ag. Syst. p. 275 (1824).

Fucodium nodosum v. *β. Mackaii*, J. Ag. Spec. Alg. p. 206.

Fucus Mackaii, Dawson Turner, Hist. Fuc. pl. 52; Harvey, Phyc. Brit. vol. i. pl. 52; non C. A. Ag. Spec. Alg. p. 87.

Ascophyllum Mackaii, Holmes & Batters, in Ann. Bot. v. (1890–91) p. 85; Oltmanns, Beiträge zur Kenntniss der Fucaceen, p. 43.

Physocaulon Mackaii, Kütz. Phyc. Gen. p. 352.

FUCUS SPIRALIS, L. = *Fucus platycarpus*, Thur.

Thallus very variable in size and form, generally 2–5 dm. long and 1–2 cms. broad; attached by a disc. Branching dichotomous or sympodial, the lateral branches variable, single or forked. Margin smooth. Air-vesicles absent or represented by irregular blister-like swellings. Cryptostomata numerous and prominent, scattered over the entire wing of thallus. Fruit-bodies egg-shaped, blunt, swollen, and often margined, generally simple. Hermaphrodite.

Var. NANA, Kjellm.

Habit dwarf. Frond 1–10 cms., tufted from the base. Cryptostomata prominent. Receptacles in some localities not produced.

Hab. On rocks in very exposed places, or on steep mud- and sand-banks in salt marshes. Blackwater Marshes, Essex; Whitby, Berwick; Dorset; Wales; Ireland: Roundstone Bay, Clew Bay; Canary Islands; coasts of Scandinavia; French coasts.

Fucus spiralis, L., v. *nana*, Kjellm. Handb. p. 11; Börgesen, in Journ. Linn. Soc., Bot. xxxix. (1909) p. 109, fig. 3. *Exs.* Holmes, Alg. Brit. Rar. Exc. Fasc. xi. (1901): Whitby. Cotton, Clare Island Survey, 1912, p. 124.

Fucus platycarpus f. *limitaneus*, Thur. et Born. Études Phycologiques, p. 41 (1878); Sauvageau, Sur les Algues du Golfe de Gascogne, p. 35 (Journ. de Bot. vol. xi. p. 268). Also Sauvageau, 1908, p. 87.

Fucus vesiculosus v. *limitaneus*, C. Montagne, Histoire Naturelle des Iles Canaries—Plantes cellulaires, Paris, 1856, p. 139; De Toni, Syll. Alg. vol. iii. pp. 206–7.

FUCUS VESICULOSUS, L.

Thallus very variable in size and form, 1 dm. to more than 1 m. long and 4–40 mm. broad, dichotomous or pseudosympodial; margins smooth; attached by a disc. Air-vesicles in pairs on either side of the midrib,

sometimes singly under the axes of the segments, or (especially in small forms) absent, hard, spherical or ovoid, equally swollen on both sides; irregular blister-like swellings also often present. Cryptostomata scattered over the wings of the thallus. Fruit-bodies mostly egg-shaped or oblong, sometimes pointed, simple or forked, compressed or swollen. Diœcious.

Megecad LIMICOLA.

Thallus not attached by disc. Reproduction by vegetative budding. Receptacles rare or absent.

Section A. Salt-marsh forms.

Thallus embedded in mud. Cryptostomata chiefly marginal, numerous, and prominent. Receptacles, when present, strictly terminal.

(*a*) Ecad *volubilis* (Turner) S. M. Baker.

Frond much spirally twisted, very variable in size and form, 4–80 cms. long and 1–16 mm. broad; margin smooth or waved. Vesicles numerous in larger plants, but often absent or few in smaller ones. Receptacles elongated, oblong or almost pointed, occurring at the ends of the fronds, hardly broader than the rest of the thallus, turgescent with or without mucilage, from 1–3 cms. in length, simple or bifid, rare. Diœcious; oogonia not dividing into oospheres; length of paraphyses variable.

Hab. Embedded in lower levels of muddy salt marshes. Coasts of Essex: Fambridge Ferry, Blackwater Estuary; Norfolk: Wells, Blakeney; Hants: Isle of Wight, Hurst Castle, Lymington. U. S. A.: Connecticut, New York. French coasts: Arcachon, Iles Chansey. Spain: San Vincente de la Barquera. Spitzbergen.

Fucus volubilis, Hudson, Flora Angl. ed. 2, p. 577 (London, 1778); S. M. Baker, in Journ. Linn. Soc., Bot. xl. (1912) pp. 283–289, figs. 5, 6, & 8.

Fucus volubilis v. *flexuosus*, S. M. Baker, l. c. fig. 7.

Fucus vesiculosus v. *volubilis*, Turner, Synopsis of British Fuci, vol. i. pp. 120 & 127 (London, 1802). *Exs.* Goodenough & Woodward.

Fucus spiralis v. *volubilis*, Batters, in Journ. Bot. xl. (1902) Suppl. p. 50.

Fucus lutarius, Kützing, Tab. Phyc. 1860, Bd. x. p. 7, and tab. 17 iii; Sauvageau, Soc. Biol. Bordeaux, 1908, figs. 16–19, pp. 106–160.

Fucus vesiculosus v. *lutarius*: *Exs.* Chauvin, Algues de la Normandie; Hohenack, Meeresalgen, No. 522.

Fucus axillaris v. *spiralis*, J. G. Ag. "Bidrag till kännedomen af Spetsbergens Alger," in Kong. Svensk. Vetensk.-Ak. Handl., Ny Följd. vol. vii. n. 8 (Stockholm, 1868) p. 43.

Fucus vesiculosus v. *spiralis*, Farlow. Collins, in Rhodora, vol. vii. (Boston, 1905) p. 229. *Exs.* Phyc. Boreali-Americana, no. 680. Johnson & York (1915) p. 62, pl. 16.

(*b*) Ecad *cæspitosus*.

Habit turfy, generally 3–6 cms. high and 1 mm. broad, membranaceous, dichotomously branched, slightly or not at all spirally twisted, midrib indistinct. Cryptostomata prominent, marginal. Air-vesicles absent. Receptacles very rare, terminal, spherical or ovoid, simple or bifid, 5–8 mm. in length. Diœcious; oogonia dividing into oospheres.

Hab. In the upper flats of peaty or muddy salt marshes. Coasts of Essex: Blackwater Estuary; Blakeney, Norfolk; Hurst Castle, Hants; Northumberland; Berwick; Argyle; Firth of Lorne; Renfrew, Gourock; Wemyss Bay; Loch Linnhe; Bute; Arran; Cumbrae; Mochras, Carnarvon; Arcachon in France.

Fucus vesiculosus v. *subecostatus*, Harvey, Phyc. Brit. vol. i. pl. 24; Greville, Alg. Britt. (Edinburgh, 1830) p. 12.

Fucus vesiculosus v. *balticus* (non J. Ag.); Hooker's British Flora, no. 267, and *Exs.* Batters, "Marine Algæ of Berwick-on-Tweed": in Berwickshire Nat. Club Trans. 1889, p. 84. Batters, in Journ. Bot. xl. (1902) Suppl. p. 50. Receptacles described: Cotton, in Proc. Roy. Irish Acad. xxxi. pp. 125–126.

Fucus balticus: *Exs.* Mrs. Griffiths, etc.

Fucus lutarius v. *arcassonensis*? Sauvageau, in Soc. Biol. Bordeaux, 1908, fig. 20, p. 131.

(*c*) Ecad *muscoides* (Cotton).

Plants very short, fastigiately branched, densely crowded together, 5–6 cms. long. Branches cylindrical or compressed, 1–3 mm. wide, not twisted, with marginal cryptostomata. Receptacles very scarce, minute, 2–4 mm. diameter. Diœcious; paraphyses not projecting.

Hab. On firm peaty salt marshes as a dense mossy turf. Roundstone and Clew Bay, Ireland; Loch Linnhe, W. Scotland.

Fucus vesiculosus v. *muscoides*, Cotton, in Proc. Roy. Irish Acad. xxxi. (1912) p. 127, pl. 6. figs. 1 & 2.

Section B. Loose-lying forms.

Thallus free; branching densely fastigiate and radial. No spirality.

Fucus balticus, Kütz. Tab. Phyc. x. Taf. 12; Gobi, Brauntange, p. 19, Taf. 2, figs. 19–22; non Ag. in Svensk Bot. tab. 516.

Fucus vesiculosus v. *balticus*, J. Ag. Spec. Alg. i. p. 210. *Exs.* J. E. Areschoug, Alg. Scand.; Rabenhorst, Krypt.-Flor. v. Deutsch. ii. p. 291.

(*d*) Ecad *nanus* (Ag.).

Margins of thallus waved and folded. Cryptostomata indistinct or absent, leading from dwarf forms 2–5 cms. in length to the attached f. *plicata*, Kjellm. Always sterile.

Hab. Sublittoral, in still water, on the sea-bottom at from 8–10 m. depth. Rågön, Trollholmen, and Småland, Baltic Sea.

Fucus vesiculosus f. *nana*, C. A. Ag. Syn. Alg. p. 5; N. Svedelius, Stud. öf Östersjöns Hafsalg. 1901, p. 84; Arcichovskij (1905), pls. 1, 3, 4.

Fucus vesiculosus f. *degenerativus*, Arc. Arcichovskij (1905), pl. 1. 9–11; pl. 3. 15–19, 27–29; pl. 4. 25.

(*e*) Ecad *subecostatus* (Ag.).

Thallus variable in size, leading from dwarf forms 2–3 cms. in length to the attached form v. *angustifolia*, Kjellm. Cryptostomata prominent, in dwarf forms marginal, in larger forms arranged in two rows on either side of the midrib. Always sterile.

Hab. Sublittoral, in still water, on the sea-bottom from 8–10 m. depth. Burgsvik, Roneham, and Slite, in Gothland; Baltic Sea.

Fucus vesiculosus f. *subecostata*, C. A. Ag. Syn. Alg. p. 5; N. Svedelius, Stud. öf Öst. Hafsalg. 1901, p. 84. *α* & *β*, Arcichovskij (1905), pls. 1 & 2.

(*f*) Ecad *filiformis* (Ag.).

Thallus very variable in size, leading from filiform plants 1·5 cms. high to the attached form v. *angustifolia*, Kjellm. Cryptostomata absent. Always sterile.

Hab. Sublittoral, in still water on the sea-bottom from lower littoral region to 5 m. depth. Lergloviken, Källvik, and Gudingefjärden, in Småland; Baltic Sea.

Fucus vesiculosus f. *filiformis*, Ag. in Svensk Bot. tab. 516. fig. *c* (misprinted *d*); N. Svedelius, Stud. öf Öst. Hafsalg. 1901, p. 84. *α* & *β*, Arcichovskij (1905), pls. 1–3.

Fucus vesiculosus f. *polytomus*, Arc. Arcichovskij (1905), pl. 1. 5–8; pl. 3. 12–13; pl. 4. 26–27.

FUCUS CERANOIDES, L.

Frond 2–3 dm. long, 0·5–2 cms. broad, plane, coriaceo-membranaceous, very delicate, linear, subdichotomous, entire at the margin, midribbed, without vesicles, but often showing extensive blister-like swellings. Lateral branches narrower than the frond, repeatedly forked, level topped, bearing fruit in their apices. Receptacles spindle-shaped or bifid, acute. Diœcious or hermaphrodite.

Megecad LIMICOLA.

Plant unattached, but lower parts embedded. Reproduction by vegetative budding. Length 5–10 cms., breadth 0·5–1 cm. Frond delicate, much curled. Cryptostomata very prominent, but not marginal. Receptacles rare. Hermaphrodite and monœcious on the same individual. Oogonia undivided.

Hab. Upper levels of brackish marshes. Keyhaven, Hants; Laira Lake, Plymouth.

PART 2.

The Relation of the Physical Factors in the Salt Marsh Habitat to the peculiar Morphology of Limicolous Fucoids.

The Essential Differences between the Rock and Salt-Marsh Habitats.

It was first of all necessary to find out whether an embedded *Fucus* could translocate water from the soil to the subaerial parts of the plant. This was done by potting up a series of blocks of marsh-mud with embedded *Fucus vesiculosus* ecad *volubilis* and keeping the ground soaked with sea-water, while the shoots resting upon the surface were not wetted. It was found that, after about a week or ten days, the subaerial parts of the plants withered away and dried up close down to the ground, while the buried parts of the thallus were perfectly vigorous. Evidently no effective translocation of water can take place from the underground parts of the thallus, and it is probably quite safe to assume that the embedded parts of a marsh *Fucus* are simply and solely an anchorage to the plant.

The first important difference between rock and marsh is the small vertical range of the marsh. This is illustrated by the diagram (fig. 14, p. 363), which has been compiled from data obtained in several localities. The levels measured have been taken in reference to an August spring and neap tide in each locality, and then reduced by simple proportion to the values they would have shown under a 13-foot August spring tide. They serve rather as an illustration than as a record of fact. The whole of the salt marsh is between high-water of neap tides and high-water of spring tides, although on the banks of channels *Fucus vesiculosus* ecad *volubilis* may extend considerably lower. This forms a narrow zone, corresponding on the shore to the zone occupied by *Pelvetia* and *Fucus spiralis*, or the uppermost zone of the rock Fucoids, and it means that the algæ are exposed for a period of several days every fortnight, a novel condition only to those algæ occupying the lower levels of the shore.

The factor which makes the salt marsh habitable to the species which naturally occupy the lower zones of the shore is no doubt the relatively high humidity, maintained throughout the long periods of exposure partly by evaporation from the wet, ill-drained soil, and, still more, during the summer months, by the transpiration of associated phanerogamic halophytes.

A second consequence of the conjunction of algæ as undergrowth with halophytic vegetation is the shade afforded by the leaves and shoots of the higher plants. Probably on account of this, marsh algæ often show deep rich colouring.

THE CORRELATION BETWEEN THE HABIT OF THE *FUCI* AND THE PHYSICAL CONDITIONS UNDER WHICH THEY GROW.

The above, then, are the main differences between rock and marsh, as far as they affect the algal vegetation. It remains to determine which of these physical factors is responsible for each of the general peculiarities of marsh Fucoids. The whole question is much simplified by the prevalence of vegetative reproduction on the marsh. This does away with the possibilities of variations, due to the crossing of different strains, and ensures that all the observed variations are actually the direct outcome of a response to changes of environment. On the other hand, it can be urged that the absence of the stimulus, obtained in the process of sexual reproduction, may cause profound modifications of a degenerative kind in the organism ; and this idea has been elaborated in a recent paper on the dwarf *Fuci* in the Baltic by Arcichovskij (1905). It is probable that some effect of this kind is produced by long-continued vegetative reproduction ; but the observations to be recorded seem to show that this is not the primary cause of the extraordinary changes of morphology correlated with the marsh habitat. In this investigation it has been found impracticable to make artificial cultures of the plants, chiefly because of the great labour involved in the provision of salt-water tides and currents, especially in a London laboratory. We have therefore relied entirely upon an ecological study of the question, *i. e.* observations under field conditions.

(*a*) THE DWARF HABIT.

The most obvious morphological peculiarity of marsh Fucoids is their dwarf habit. The origin of this dwarfing has been chiefly studied by means of the varieties of *F. vesiculosus* ; but the main principles observed seem equally applicable to the other species.

Effect of Physical Factors upon the Morphology of F. vesiculosus *megecad* limicola.

The simplest way of finding out the correlation between the physical environment and the morphology of a particular plant is to study intensively the distribution of the varieties of that plant in as limited an area as possible. This is the plan we have adopted in the case of the highly variable *F. vesiculosus* megecad *limicola.* In the system of marshes fringing the estuary of the River Blackwater in Essex, the plant is abundant, and it shows there an amazing range of form. The chief marshes are shown in line shading in the sketch-map (Pl. **30**) taken from the ordnance survey of the district. The soil of the marshes is very uniform, being composed everywhere of a rich black mud.

A. *Effect of Changes in Salinity of the Water on the* Fucus.

Travelling up the River Blackwater, from Mersea Island to Northey Island, the salinity of the water in the channel decreases considerably. The amount of this change must vary greatly with the state of the tide and the drainage of rain-water into the river-basin ; but we had not the opportunity of collecting a series of samples at different stations to obtain comprehensive data. One series of salt-water samples was, however, taken, on April 12th, 1914, upon a moderate spring tide in fair weather, which may be taken as representing tolerably average conditions.

The concentration of chlorides, calculated as sodium chloride, at four stations at high-tide in mid-channel, is given below; at the first three stations this value was calculated by taking the mean of two observations, one taken on the rising and the other on the falling tide :—

Opposite Ray Island	2·85 per cent. NaCl.
Opposite Tollesbury	2·82 per cent. NaCl.
Opposite Osea Island	2·75 per cent. NaCl.
Opposite Northey Island	2·58 per cent. NaCl.

On this day there was about 10 per cent. decrease in the concentration of salt, at the island furthest up the river ; but no doubt after rain, or at the neap tides, a very much greater dilution may occur.

The effect of this dilution on the morphology of the marsh *Fucus vesiculosus* is very striking. In the various marshes lining the river, from the mouth to Northey Island, there is a gradual and progressive attenuation in the thallus of the *Fucus*, until at Northey Island, the longest specimens have the appearance figured (fig. 15, p. 366) of a slightly flattened skeleton *Fucus* showing moderate spirality. This attenuation was shown, but to a less extent, in the smaller forms.

In this connexion, it is interesting to notice that Techet (1908), experimenting on several genera of brown, red, and green marine algæ, none of them, however, closely allied to *Fucus*, showed, by means of detailed cultures, that in general a decrease in salinity of the water caused the algæ to assume a form more slender and less branched than under normal conditions.

B. *Effect of Exposure to the Atmosphere.*

The different levels of any one marsh are covered by a different number of high tides—a drop of a few inches in level being sufficient to allow access to one or more extra tides in each fortnightly cycle. This means that the higher levels suffer from two disadvantages : (*a*) the exposure at the neap tides is prolonged by several days ; (*b*) the opportunity for the absorption of water

and nutrient salts are decreased, both by the fewer tides covering these levels and by the shorter period of immersion per tide.

The conjunction of these two factors leads to a general dwarfing of the thallus, together with a decrease in spirality; so that, in all the marshes, the uppermost levels are occupied by the minute turf-like forms of the e. *cæspitosus* type, and the lower levels by progressively broader, longer, and more twisted forms.

Further, in the Ray marshes, along the creeks, that is at the lowest levels of distribution of the *Fucus*, the intermediate forms are always found at the mouths of the creeks, while the large, luxuriant specimens, with long, broad, much twisted thallus, are found in the creeks in the body of the marsh. This is probably because, at corresponding levels, the current is swifter along the narrow channels than at the mouth of the streams, and the *Fuci* have, therefore, a greater access of nutrient salts and dissolved gases during their short immersion by the tide.

From these data, taken concurrently, one deduces that :—

(*a*) Exposure to the atmosphere alone induces a shortening of the thallus.

(*b*) Lack of nutrient salts, either through low salinity of water, short time in water, or sluggish current, induces a narrow thallus; and, conversely, abundance of nutrient salts and dissolved gases makes for a broad, crinkled, and twisted thallus.

These observations upon *F. vesiculosus* megecad *limicola* are confirmed by more general considerations. A reference to the table (p. 348) will show that the only marsh species which have a dwarfed habit are those derived from the lower levels of the rocky shore (see diagram of zonation on marsh and shore, fig. 14, p. 363). These Fucoids in the transition from rock to marsh have had their normal time of exposure by the tide increased, while their normal time of immersion has been decreased by the change. For this reason the change is associated with a dwarfed habit, which is not a necessary attribute of marsh Fucoids, as is shown by the normal size of *Pelvetia canaliculata* ecad *libera*, and also by occasional plants of marsh *Fucus vesiculosus* growing low down on the banks of deep streams, which may reach large dimensions (1 metre or more in length).

The first general characteristic of the limicolous Fucoids—their dwarf habit—may therefore be referred primarily to two co-operating factors,—the lengthened exposure, which causes a shortening of the thallus, and the reduced immersion in sea-water, often accompanied by dilution, which causes a narrowing of the thallus.

It is to be noted that the connexion between dwarf habit and long exposure is not limited to the limicolous Fucoids; but, as is well known, the dwarf varieties of rock species, *e.g.* the var. *nana* of *F. spiralis*, the var. *distichus* of *F. inflatus* (see Börgesen, 1908, p. 720), or the var. *minor* of *Ascophyllum*,

are characteristic of an exposed habitat; here compare also Cotton's interesting account of the short varieties of *Fucus ceranoides*, about 1 in. only in length, occurring at the *Pelvetia* level in the Newport River (Clare Island Survey, 1912, p. 85).

Although these deductions probably hold in a general way, there are no doubt other factors which must be taken into account in special cases. For example, the most minute form of *Fucus vesiculosus* megecad *limicola*, the ecad *muscoides* (Cotton), is characteristic of peaty marshes, and it is possible that the acidity of the soil has a further dwarfing effect on the plant. Arcichovskij (1905) finds that the contamination of water with organic debris (*e. g.* in the Kiel Canal) leads to a dwarfing of the *Fuci*.

(*b*) Spirality or Curling.

It has been difficult to obtain direct evidence correlating the curled, twisted, or spiral habit, shown by practically all marsh Fucoids, with any special

Fig. 12.—*Fucus vesiculosus* proliferations experimentally produced on the Samphire Marsh, Blakeney. Nat. size.

factors in their new habitat; this is largely because the contortions of these plants are a very constant character, and where variations occur they are not so directly influenced by changes in physical conditions as the variations in size which have just been under discussion. This is illustrated by the two specimens of *Fucus vesiculosus* ecad *volubilis* (figs. 4 & 5, pp. 333 & 334), which were found interwoven in the middle zones of the Blackwater marshes, and yet show a great difference in spirality.

There were, however, two conditions in which spirality in *Fucus vesiculosus* megecad *limicola* became markedly reduced. The first was under low concentration of salt water, as shown in the attenuated forms (fig. 15, p. 366); the second on the assumption of the upright turf-like habit, as in the ecads *cæspitosus* and *muscoides*. Similarly, the turf-like *Pelvetia canaliculata*

ecad *coralloides* shows only slight curling. From this we think it probable, first, that the phenomenon of twisting is correlated with access of nutrient salts, and, secondly, that it is connected with the recumbent habit of the plants. Salt-marsh Fucoids are only lifted gently by the tide when it covers the marsh and deposited again at the ebb in their original position; this

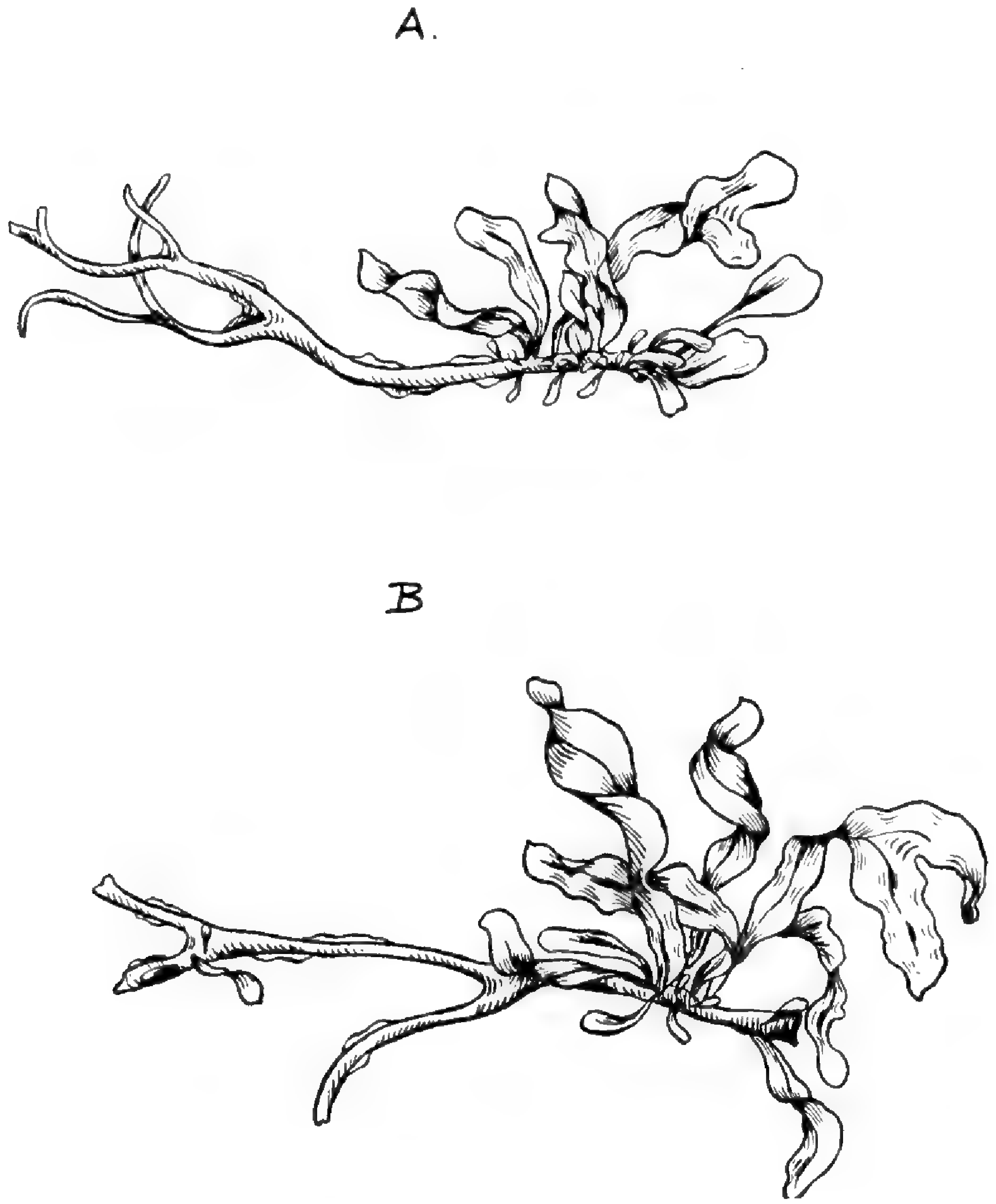


Fig. 13.—*Fucus vesiculosus* proliferations experimentally produced on the Samphire Marsh, Blakeney. Nat. size.

may be well seen in the free-growing *Pelvetia* of the Blakeney marshes. Hence in the intertidal periods one side of the plant, the lower, is always in contact with wet soil charged with nutrient salts, and tends to lengthen, and so contortion of the thallus results. In the free-growing *Pelvetia* this takes the form of curling, which is always away from the soil. This tendency to spirality or contortion disappears in a plant like *Fucus spiralis* var. *nana*, which does not grow in the placid seclusion of the marsh, but upon the mud-

cliffs lining the main channels, where it may be buffeted by waves and currents and where it hangs loosely over the concave banks and does not recline upon the mud.

Although these conclusions may hold in a general way, they do not seem sufficient to account for the spirality of *Fucus vesiculosus* e. *volubilis*. The experimentally produced vegetative shoots of that species (figs. 12 & 13), although they show a good deal of curling and some spirality, had not nearly the spirality of corresponding shoots from the ecad *volubilis* produced in close proximity to the experimental plot. Johnson & York (1915) report from a similar experiment in Cold Spring Harbour (p. 62) that 6 ins. of spirally twisted thallus arose on the marsh in six months. It is probable that there is some hereditary tendency to spirality in the true marsh form, which is easy to understand, because the possession of a curled or twisted thallus, whereby it may secure an anchorage by entanglement with marsh vegetation, is a great asset to a limicolous *Fucus*. Intense spirality is an occasional character of attached *Fucus vesiculosus*, especially when the plants are spread out over mud; we have found certain plants as much spirally twisted as the marsh varieties. It is evident that the vegetative offspring of such parents have distinct advantages in the salt-marsh habitat, and also that any variations in the direction of increase in spirality caused by irregularities in the distribution of nutrient salts will tend to accumulate by selection.

(*c*) Vegetative Reproduction.

The substitution of vegetative methods of reproduction for normal reproduction by means of oospheres and antherozoids, which was first recognised and described in detail by Sauvageau (1908, pp. 164–165) for *Fucus vesiculosus* megecad *limicola*, is very general among marsh Fucoids. In trying to correlate this peculiarity with the new environmental conditions obtaining on the marsh, the question divides itself naturally into two parts. First, what factors cause the abortion of the sexual organs, and, secondly, what causes the great production of vegetative shoots, under marsh conditions?

A. *Abortion of the Sexual Organs.*

In the first place it will simplify matters to eliminate some of the possible factors which might influence the production of sexual organs. The abortion of the reproductive bodies is obviously not correlated either with exposure or the access of nutrient salts, or we should find, as in the case of the dwarf habit, where these were the determining factors (see p. 358) that the *Fuci* from the uppermost zones were normal in this respect, whereas *Pelvetia* is the most consistently sterile of all the marsh Fucoids. Also it cannot be due to the absence of an attachment disc, as Svedelius (1901, p. 85) has suggested, for *Ascophyllum nodosum* ecad *Mackaii*, a free-growing form, fruits normally.

None of the species showing true marsh forms are devoid of traces of sexual reproduction, and it is to the distribution of the rare receptacles that we must look for evidence as to the factors which prevent the production of sexual organs on the marsh.

The first fact which appeared was that the presence of halophytic vegetation was distinctly prejudicial to the production of fruit-bodies on the associated Fucoids. Thus, both *Fucus vesiculosus* megecad *limicola* and *Ascophyllum nodosum* ecad *scorpioides* are frequently found in fruit during the spring and summer in stations, such as stream-banks or bare mud-flats, where halophytes have not yet colonized the ground ; but they hardly ever fruit when they are associated as undergrowth with phanerogamic vegetation. This holds both in the Blackwater marshes and at Blakeney for the ecad *volubilis* of *F. vesiculosus*; and Mr. Cotton tells us that the fruiting specimens of the tiny ecad *cæspitosus* and ecad *muscoides* found at Clew Bay, Ireland, were also confined to stream banks or the periphery of the marsh, while the general undergrowth vegetation was sterile.

A rather unexpected confirmation of these observations was the finding of three fruiting specimens of the free-growing *Pelvetia* by Prof. Oliver in January 1915. *Pelvetia* does not normally fruit to any extent in the winter months, and it seemed remarkable that such an unusual phenomenon as fruiting on the free-growing form should occur exactly at the season when fruiting is least common on the attached plant. The incongruity is explained by the reduction in the foliage of *Aster* and *Salicornia*, among which the *Pelvetia* was growing, during the winter months.

There are two conceivable methods by which the presence of phanerogams might influence the accompanying undergrowth, either by affording shade (or reducing CO_2) and so decreasing its photosynthetic activity, or by contributing to the humidity of its surroundings during the periods of exposure and so preventing changes in the concentration of its cell-sap. The former hypothesis, that light was the determining factor, was especially promising in view of the observations of Lloyd Williams (1904 & 1905) on *Dictyota dichotoma*, which produces its sexual organs at regular intervals, governed by the good illumination prevailing at low spring tides.

It happens, fortunately, that at Blakeney Point there is the means of testing these alternative hypotheses. The great *Pelvetia-Salicornia* marshes in that area are intersected by a shingle beach, crowned with sand-dunes, called the Long Hills (see sketch-map, fig. 1, in Baker, 1912). Along the lower edge of the north-western slope of this shingle-beach, there is a zone, about 2 feet wide, of normal *Pelvetia canaliculata* attached to pebbles, which are held rigid in a shallow layer of mud. The ground slopes towards the marsh and the shingle immediately below it affords good drainage, so that, in the intertidal periods, this zone becomes very much drier than the flats of the salt marsh, which are vertically only a few inches below it. These

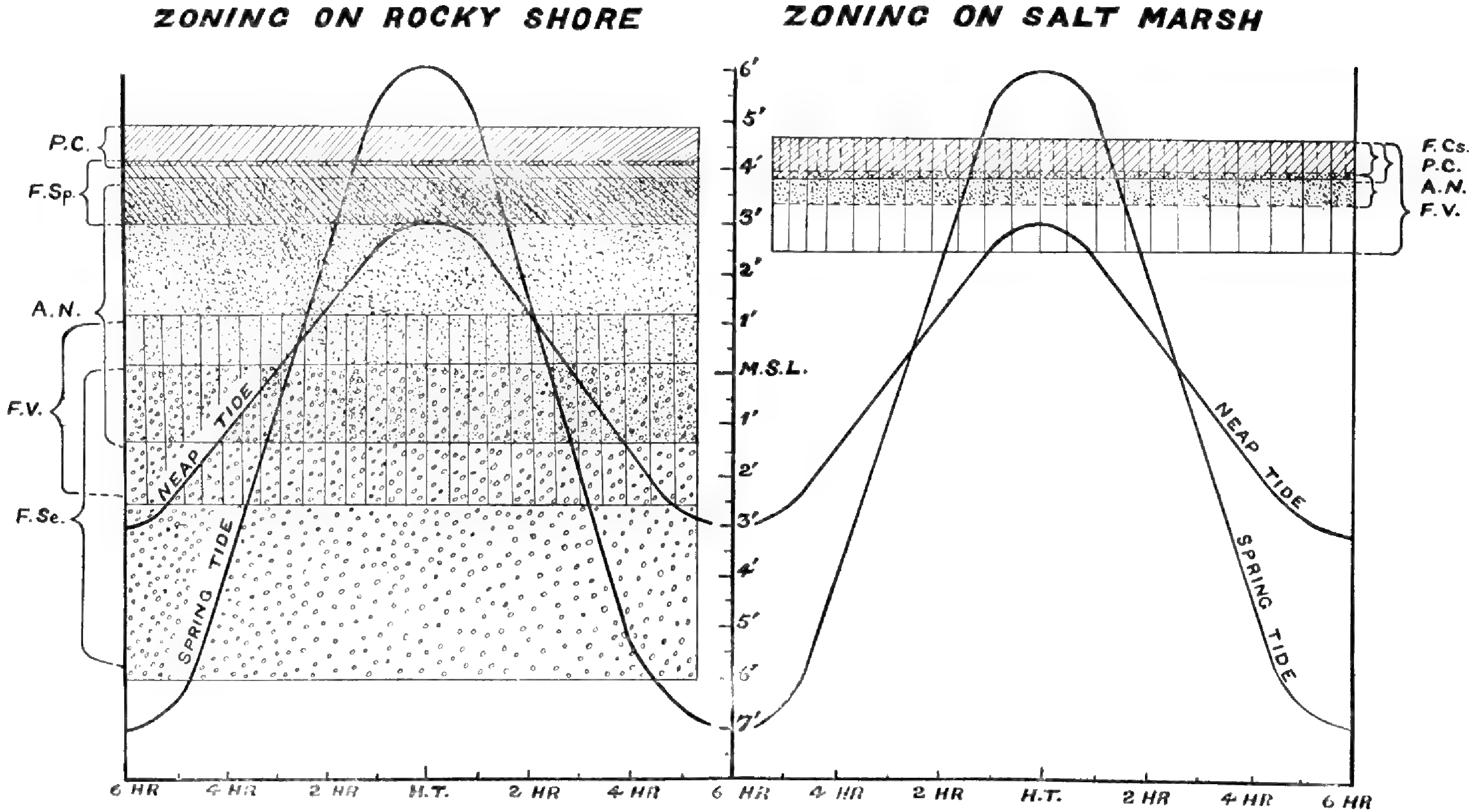


FIG. 14.—Diagram illustrating the relative distribution of Fucoids on a sheltered shore and on the salt marsh.

P.C. = *Pelvetia canaliculata*. *F.Sp.* = *Fucus spiralis*. *A.N.* = *Ascophyllum nodosum*.
F.V. = *Fucus vesiculosus*. *F.Cs.* = *F. vesiculosus* ecad *cæspitosus*. *F.Se.* = *Fucus serratus*.

All values reduced to a thirteen-foot spring tide. Values on rock taken at White Cliff Bay, Isle of Wight, except *Pelvetia*. Values for *Pelvetia* and marsh *F. vesiculosus* at Blakeney Point. Values for marsh *Ascophyllum* determined only by its position in the *F. vesiculosus* zone at Mersea Island.

Vertical scale = height in feet from mean sea-level. Horizontal scale = time in hours from high tide.

plants of attached *Pelvetia* are therefore exposed to similar conditions of desiccation during neap tides to those they would experience on a rocky shore. But, immediately above the *Pelvetia* zone, there is a belt of *Suæda fruticosa* bushes. These are sufficiently high (about 6 or 8 inches clear of the ground) not to interfere with the movement of air around the algæ; but, being on the south-easterly side of the plants, they afford a deep shade, which covers many of them throughout practically the whole day. The shade from these *Suæda* bushes is certainly deeper than that thrown by the close ranks of *Aster* or *Salicornia* on the salt marshes. In spite of this shadow, all the *Pelvetia* plants fruit freely and abundantly, and the receptacles produced are perfectly normal. No essential difference could be found between plants grown under the shade of the bushes and those which were exposed to full sunlight.

From this we concluded that the humidity of the salt marsh in the intertidal periods, due partly to the retention of water by the flat, undrained soil, and partly to the transpiration of the halophytes, is the primary cause of the sterility of marsh Fucoids.

This hypothesis agrees well with other observations. The only two species which produce an abundance of normal fruit-bodies on the salt marsh, namely, *Fucus spiralis* v. *nana* and *Ascophyllum nodosum* ecad *Mackaii*, both grow in comparatively exposed positions, where the humidity might become low in the intertidal periods. *F. spiralis* v. *nana* hangs on vertical or sloping mud-banks, usually destitute of halophytic vegetation; while *A. nodosum* ecad *Mackaii* is described as lying in masses on mud, sand, or pebbles among boulders upon the seashore, in situations certainly less exposed but quite analogous to the habitat of the ordinary attached plant.

Further evidence is afforded by the marsh forms of *Fucus ceranoides* found at Keyhaven, Hants. Here large, apparently normal, plants grew on the marsh, attached to the rhizomes of rushes, as well as the unattached dwarf marsh form; yet these attached plants, evidently derived from fertilized oospheres, showed exactly the same abortion of the sexual organs as the dwarf marsh plants. This derangement of the sexual organs affected them in two ways. First, the oogonia were not divided; secondly, the proportion of the sexes in a normally hermaphrodite conceptacle became variable, so that on the same plant receptacles of either sex might be produced, together with all intermediate stages between that and the hermaphrodite condition.

These observations indicate that the humidity of the marsh habitat prevents a certain concentration of the cell-sap, requisite for the production of sexual organs. Probably this is of the nature of a stimulus, for we have not been able to trace any difference in the fertility of plants taken from the wide vertical range of *Fucus vesiculosus* on a rocky shore, nor is there any correlation between the time of liberation or production of gametes and the

spring and neap tides. This indicates that, provided a certain limiting concentration is reached, the time for which this is maintained is immaterial, and in the ordinary way this concentration is reached during every exposure by the tide.

In this connexion we notice with great interest that Farmer and Williams (1898, p. 623) were only able to obtain good material for the first division of the oogonium nucleus, in *Fucus* and *Ascophyllum*, just after the plants were covered by the flowing tide. Similarly, Yamanouchi says (1909, p. 47) :— "There are several points of interest in regard to the relation between the frequency of mitotic figures" (in *Fucus vesiculosus*) "and environmental conditions, both in the oogonium and antheridium and the young thallus. In general, the plants, collected one or two hours after being covered by the tide, were full of figures." These cytological observations seem to show that the stimulus, due to the concentration of the cell-sap by tidal exposure, takes effect only upon the recovery of normal concentration, when the plants are again covered by sea-water, and then the oogonia or antheridia at once proceed to divide. If this is so, interesting information about the time taken by both mitotic and amitotic divisions might be collected by fixing fucaceous conceptacles, at measured time-intervals, after their first immersion by the tide.

However, the subject bristles with difficulties. For example, a normal individual of any one of these Fucoids will continue to produce and ripen its sexual organs, without any tidal exposure, in the laboratory for at least two to three months. Also six full-grown fruiting plants of *Pelvetia canaliculata*, which were cut away from their supporting stones and pegged out in the midst of the marsh, were still producing oogonia and antheridia in a perfect state of development after two years under marsh conditions. The process, which seems to require certain concentration conditions for its inception, appears to become habitual in the adult plant. It is, of course, a well-known observation that the escape of ripe egg-cells and spermatozoids from the conceptacles in *Fucus* is caused by exposing fertile branches to humid air (see Thuret, 1854, and Oltmanns, 1889), but even this phenomenon can continue for some time without exposure (*cf.* Pierce, 1902). We have not been able to follow up any further the many interesting points raised by this question, both as to the exact rôle of changes in concentration of cell-sap in growth and cell-divisions and as to the persistence of the habitual process.

B. *Vegetative Budding in Marsh Fucoids.*

This second phenomenon arising in connexion with the reproduction of marsh Fucoids is so general among them that we have not been able to correlate it with any special factor in the habitat. It is not a unique property

of marsh Fucoids, being very general among attached plants, but there, from the very nature of their origin, the new shoots can only replace weatherworn parts of the thallus and never maintain a separate existence. The fact that

FIG. 15.—*Fucus vesiculosus* megecad *limicola* ecad *volubilis*. $\frac{1}{2}$ nat. size.

Attenuated form produced by low salinity of sea-water. Northey Island, Essex.

in attached plants vegetative shoots arise chiefly in the lower covered parts of the thallus and during the winter months, leads us to surmise that a low concentration of the cell-sap, or humidity during exposure, favours the production of such buds.

The Cryptostomata of Fucus vesiculosus *megecad* limicola.

The prominence of cryptostomata and their marginal position is a very marked feature of the salt-marsh varieties of *F. vesiculosus.* These curious organs are also very prominent in the marsh *F. ceranoides.* We have not been able to examine the question of the cause of this in detail, but probably future work may throw some light on their function. It is, however, to be noted that, in *Fucus vesiculosus*, the cryptostomata increase in relative size and frequency and become more and more strictly marginal in position as the habitat becomes more exposed. Their presence in great abundance is a criterion of a faculty for the endurance of prolonged exposure, both in rock and marsh forms.

Application of these Principles to the Morphology of the Loose-lying Fuci *of the Baltic.*

In the Baltic Sea three dwarf forms of *Fucus vesiculosus* form the chief constituents of one of the loose-lying formations characteristic of sheltered lagoons in that tideless sea. These have been described in some detail by Svedelius (1901), whose work upon them has been summarized in a previous paragraph (Part 1, p. 338). In form they approach closely to the ecad *cæspitosus* of the limicolous *Fucus vesiculosus*; but at first sight their habitat seems to have very little in common with the salt-marsh habitat. They occur in large masses quite unattached, on the sea-bottom, at a depth of 8–10 metres, in places where there are no currents.

Their most striking morphological peculiarity is their extremely dwarf habit. We have seen that in the marsh Fucoids a dwarf habit is correlated with increased exposure by the tide. In this formation the reverse change has happened and the plants are never exposed. In spite of this the change in essential physical conditions is not wholly dissimilar. We know too little about the physiology of the *Fuci* to say what "exposure" or its concurrent consequence—a shortened immersion in sea-water—means. In the case of marsh *Fuci* we were able to unravel one of the complex of possible factors operating in "exposed" conditions and to show that the narrowing of the thallus was directly attributable to a decrease in the access of nutrient salts, brought by the sea-water. In the Baltic loose-lying formations the same factor operates from a different cause. The salinity of the Baltic Sea is low in the first place, and in the second place the stillness of the water about the loose-lying algæ prevents their using the salts from any but the actual water they occupy. This lack of nutrient salts then explains the extreme tenuity of the Baltic forms, which may reach filiform dimensions. Svedelius (1901, p. 85) considers the narrowness of these forms to be due to the incessant lack of the new recruiting forces of sexual reproduction in the loose-lying forms; so that "the broadest loose-lying forms are those which last altered their

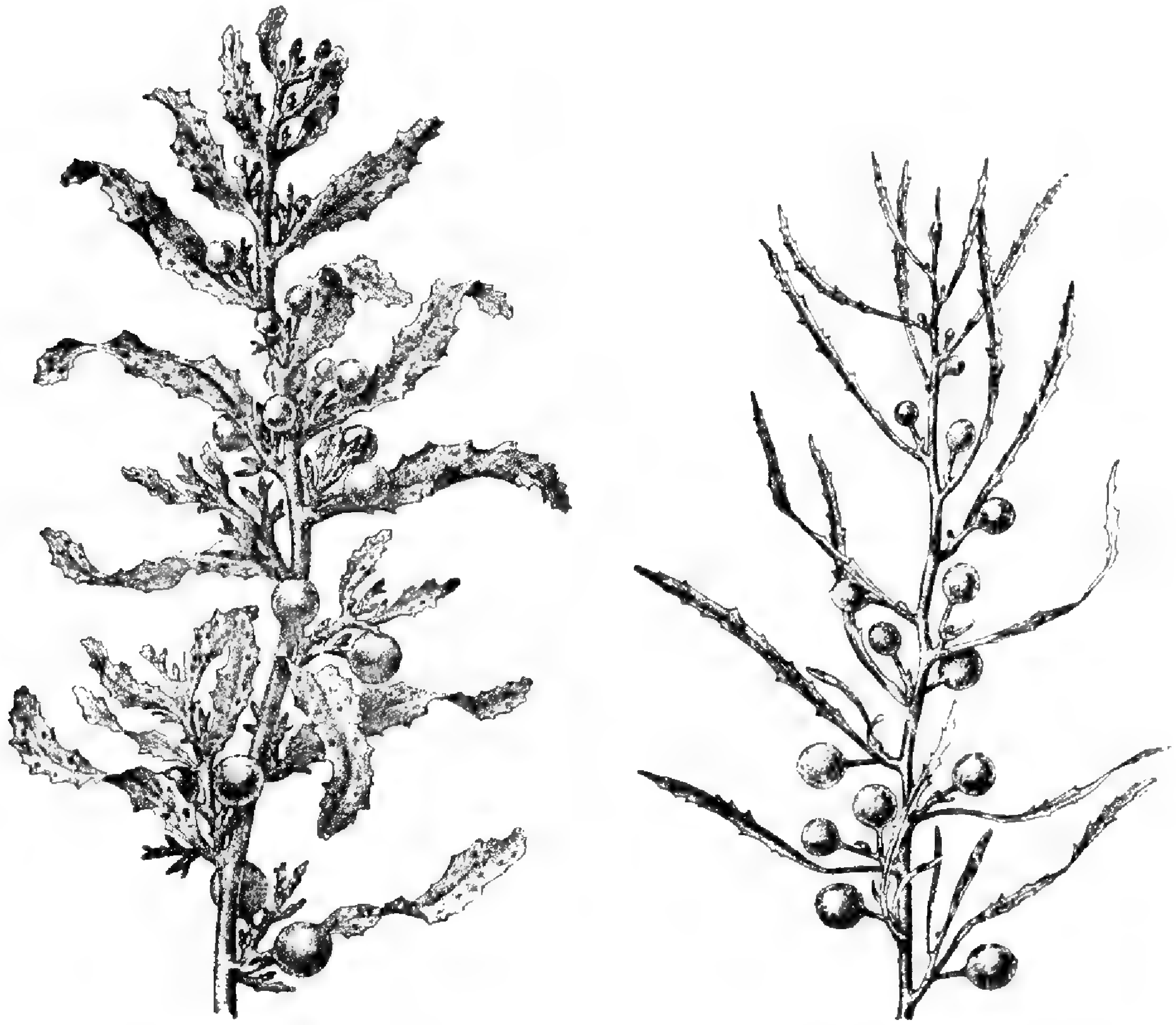
condition of life, and, on the other hand, those which have the narrowest thallus are the oldest." Arcichovskij (1905, part ii.) also emphasises the effect of phyllonecrosis in producing dwarf forms, coupling with it, as subsidiary causes, the dilution of sea-water and its contamination with organic debris. This effect, however, is clearly shown not to apply to *Fucus vesiculosus* in general, from the specimen figured (fig. 16), in which the vegetative offspring or "older shoot" of a narrow form is a very broad form. The "exposure" of a *Fucus* may curtail its nutritive possibilities in another way, by reducing the time of immersion in water charged with CO_2, always supposing that photosynthesis in a marine alga can only take place under water, a supposition for which the experimental evidence has not

FIG. 16.—*Fucus vesiculosus* megecad *limicola* ecad *volubilis*. Nat. size. Plant showing vegetative production of a broad form from a narrow form.

yet been obtained, but which seems probable. If so, the dwarfing of these immersed forms takes place in a similar way, by curtailing photosynthesis; first, by the reduced light intensity, at the depth where they grow, and, secondly, by the short supplies of CO_2, due to the quietness of the water.

The rigid absence of sexual reproduction in the loose-lying *Fucus vesiculosus* is precisely what one would expect in the uniform concentration of the tideless and currentless sea-water in which they grow; in the same way, there are no serious concentration differences over the upper and lower surfaces of the thallus to induce spiral coiling or twisting. Hence the plant is symmetrically branched in a radial fashion and shows no spirality.

On the other hand, the forma *membranacea* of *Fucus inflatus*, decribed by Rosenvinge (1898, p. 46) and in more detail by Jønssen (1904, p. 20), seems to be anomalous. It grows in a loose-lying formation off the coasts of Greenland; but it is in full fructification from March to August, and its habit is curled and twisted. *Fucus inflatus* is characteristic of the lowest levels of the littoral region; this interesting form seems worthy of a detailed study.



A. B.

FIG. 17.—A. *Sargassum vulgare*, C. Ag.
B. *Sargassum natans*, L. (After Börgesen.)

Application of the same Principles to the Morphology of the Sargasso weed.

Of all the unattached Brown Algæ the most famous is the gulf-weed, found floating in large masses in the Sargasso Sea. Many authors, following Kuntze (1881, p. 197), have been content to regard this vegetation as derived entirely from detached specimens, torn away from the reefs on the West Indian coasts. This idea has been strongly combated by Sauvageau (1907), and recently Börgesen (1914, pp. 1–20) in a paper

based upon personal observations in the field, has shown conclusively that the gulf-weed is a true floating form, reproducing itself indefinitely by the vegetative elongation of the thallus combined with a gradual disintegration of the older portions.

In discussing the probable origin of the gulf-weed, Börgesen considers that it has been derived, probably at a remote period of time, from detached specimens of a saxicolous *Sargassum* and that the change in habitat has "induced an appearance very distinct from the original attached form." He considers the most probable ancestors of *Sargassum natans*, L., as either *S. vulgare*, C. Ag., or *S. filipendula*, C. Ag. Similarly, *S. fluitans*, Börg., is probably derived from *S. Hystrix*, J. Ag. (Börgesen, 1914, p. 222, Phæophyceæ). It is interesting to see how far the change in morphology, in such a transition, is similar to those we should expect from an examination of the detached Fucoids.

Fig. 17 A & B, which are taken from Börgesen's paper on *Sargassum* (1914), show the morphology of the attached *Sargassum vulgare* and its vegetative offspring in the floating condition, *S. natans*. The physical conditions under which the floating gulf-weed lives are essentially identical with those operating upon the loose-lying *Fuci* with one important exception. Thus we have a uniformity in concentration, both in time and space, which induces (*a*) abortion of the sexual organs and (*b*) lack of spirality or contortion. Secondly, although the Sargasso weed lives in the great ocean-currents, which would seem to give it access to unlimited supplies of nutrient salts, in reality, as the plant floats and so moves with the water, it will suffer from a shortage of nutrient salts, because it can only lay under contribution the volume of water which it occupies, while an attached plant may absorb salts from much larger volumes of water. Hence the attenuation of the thallus, which is the most characteristic morphological peculiarity of the Sargasso weed, is probably directly induced by its floating habit. In the case of the loose-lying Fucoids, we saw that the other factor in their dwarf habit —the shortening of the thallus—was probably due to a curtailment of photosynthesis owing to low illumination and shortage of CO_2; but the Sargasso weed suffers from neither of these disadvantages. It floats on the surface and so has abundant light, while the rich fauna, which takes refuge among its branches, must afford an ample supply of CO_2. Hence we do not get shortening combined with the attenuation of the thallus in Sargasso weed; if anything, the foliose fronds are longer in the floating variety than in the attached plant. The last morphological peculiarity of the floating *Sargassum*—the absence of cryptostomata upon its thallus—is analogous to the absence of cryptostomata in the ecad *filiformis* series of the loose-lying forms of *Fucus vesiculosus*, but we do not understand the significance of these organs.

We see, therefore, that all the morphological peculiarities of the floating

Sargasso weed can be explained in the same terms as those of the limicolous *Fuci*, and this affords a strong confirmation of Börgesen's contention, that the two floating species, *Sargassum natans* and *fluitans*, are direct vegetative descendants of the saxicolous Sargassums, which continue to propagate themselves indefinitely, by vegetative means, under the new conditions.

PART 3.

Relative Distribution of the Marsh Fucoids.

The various species of Brown Algæ which occur in salt marshes are by no means an inconspicuous component of the marsh vegetation. They may function in three ways in the economy of the marsh as :—

(*a*) Pioneer vegetation ;
(*b*) Undergrowth ;
or (*c*) Vegetation of eroded surfaces.

(a) *Brown Algæ as Pioneers.*

There is only one species which seems at all important in this connexion, the ubiquitous *Fucus vesiculosus* megecad *limicola*. Occasionally small bunches of *Ascophyllum nodosum* ecad *scorpioides* may be found in similar situations, but never in sufficient quantity to have any marked effect on the topography.

When, either by the accumulation of silt or the protection of the locality, an area of mud or sand becomes sufficiently stable, it is at once colonized by sand-binding algæ. The most important of these, in the earliest stages, seem to be various species of *Enteromorpha*, *Rhizoclonium*, *Vaucheria*, and *Microcoleus*.

At Mersea Island, as well as at Blakeney, *Enteromorpha* comes in first, and, after the ground has reached a certain level, either *Rhizoclonium*, *Microcoleus*, or *Vaucheria* may follow it and build up the mud-bank very rapidly. When a certain level has been reached the ground becomes infected with *Fucus*, which forms a dense tangled vegetation, and no doubt assists materially in the accretion of mud and the stabilization of the bank, besides affording humus by the decay of its subterranean parts. When buried by the deposited silt, the *Fucus* has the property of pushing up fresh shoots to the surface from its underground parts, and this happens pretty rapidly (the process is illustrated in fig. 18). The new marsh at Blakeney, called the Samphire Marsh (Oliver, in Journ. of Ecology. 1913, p. 13), which is being rapidly built up from a sterile mud-bank, shows the function of this *Fucus* in a particularly striking way. Every bare area in this marsh is being overgrown by vigorous *Fucus* plants, and, after these are established, seedling Salicornias inevitably follow closely. An accreting bank under *Fucus* is shown in Pl. **28**.

Generally, the green algæ persist with the *Fucus*, *Enteromorpha*, especially, forming a common undergrowth in the Mersea marshes. Very shortly after the colonization of a mud-bank by *Fucus*, seedling halophytes begin to grow up through the dense algal vegetation, and so the mud becomes a salt marsh, and throughout its earlier stages, *i.e.* at the lower levels, the *Fucus* persists as an undergrowth.

In many localities the green and blue-green filamentous algæ, always conspicuous as sand- or mud-binders, in the earliest stages of colonization, form the only algal vegetation of large areas of salt marshes. Compare Gomont's report on the saltings of Lorraine (Gomont, 1908, pp. 29–38), where Cyanophyceæ, especially *Lyngbia Aestuarii* and *Microcoleus chthonoplastes*, are the predominant algal vegetation, and no brown algæ are represented at all.

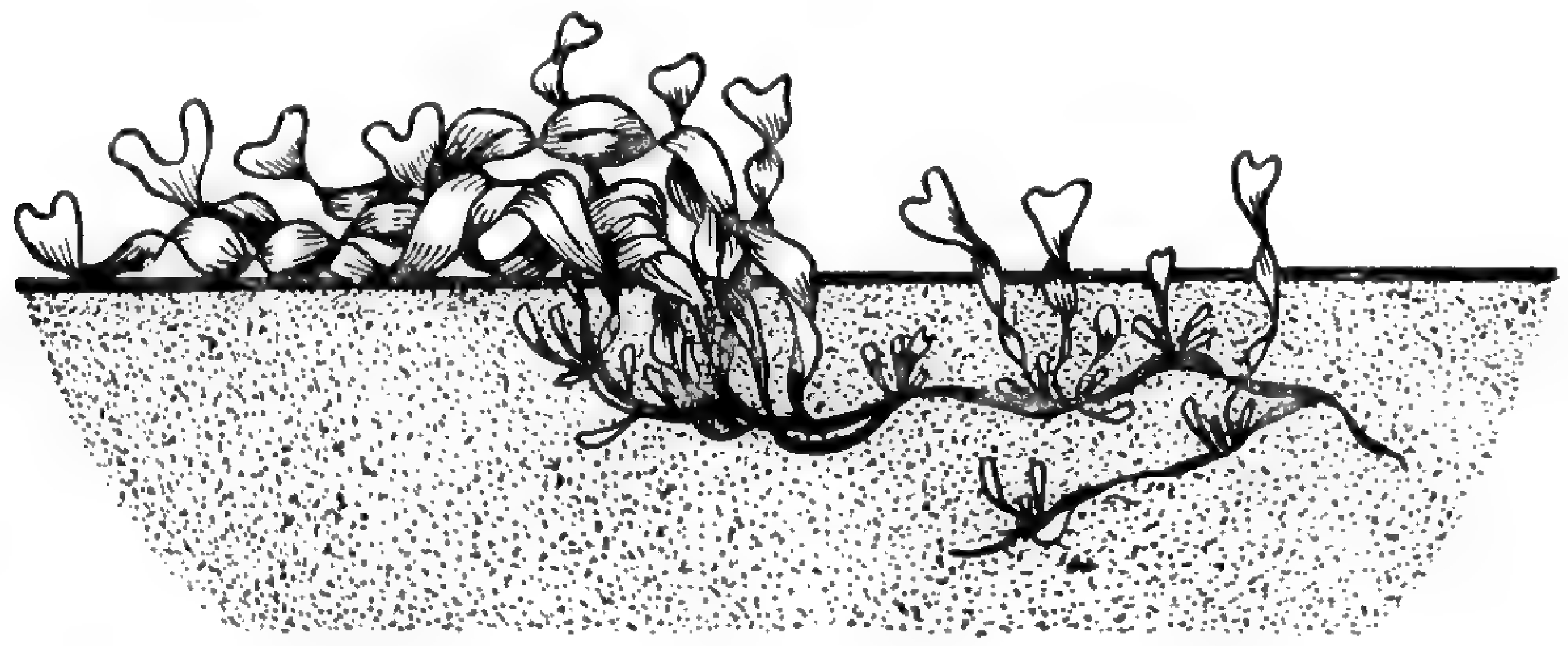


FIG. 18.—*Fucus vesiculosus* megecad *limicola*.

Showing vegetative sprouting from buried parts of the thallus, through an accreting mud-bank.

But where the Fucoids enter into a salt marsh they naturally become the chief vegetation over the marsh surface, owing to their large size and luxuriant habit, and the Cyanophyceæ and Chlorophyceæ are then restricted to mud-flats and stream-banks, where *Fucus* cannot obtain a footing, or else they may persist as a ground flora beneath the *Fucus*.

(b) *Brown Algæ as Undergrowth.*

The most characteristic function of the marsh algæ is that of a dense undergrowth around the phanerogams. The halophytes serve as anchorage and protection from excessive scour to the algæ, and the algæ, in their turn, form an incubation bed for the seedling halophytes, and also prevent undue evaporation from the marsh soil. The beneficial effect of an undergrowth of *Pelvetia* upon *Salicornia europæa* has been shown experimentally by Oliver (in Baker, 1912, p. 282), and no doubt a similar benefit is conferred by other algæ, functioning as undergrowth. Pl. **29** shows an undergrowth of *Ascophyllum nodosum* ecad *scorpioides* with *Aster*.

Vertical Zonation of the Marsh Fucoids.

The Fucoids occupy a definite vertical range in the salt marsh, in the same way as they have a definite position upon the seashore. The lower limit of this range seems to be determined solely by the mobility of the ground; for on the sheltered banks of deep creeks the limicolous *Fucus vesiculosus* may extend several feet below the level of the marsh. The upper limit is, however, well defined, and differences of an inch or two in level may determine the persistence of a species, with great precision. In no case have the algæ been found to extend above the more or less mobile part of the salt marsh, unless it be as occasional relicts (*cf.* Oliver, in Journ. of Ecology, 1913, p. 12).

The nature of the phanerogamic overgrowth seems to be immaterial: thus *F. vesiculosus* megecad *limicola* occurs with *Spartina* in the Hurst Castle, French, and American marshes; with *Aster* and Salicornias at Blakeney and Mersea Island, and under the small ecad *cæspitosus* with a close *Glyceria-Armeria* turf at Mochras, Carnarvon, and Clare Island. It is possible that some of the variations in form noticeable in specimens of this species from different localities may be partly due to differences in illumination, etc., referable to the different aspect of the associated phanerogams. The Fucoids disappear as a rule in well-established saltings, such as the Marams in the Blakeney area, or where they penetrate, as they do in the Blackwater marshes, they are rigidly confined to the banks of creeks and channels.

The vertical range of the mobile flats of the salt marsh is only about 12 inches over all, with an 18-ft. tide; but there may be a definite zonation of the algal undergrowth, within this range. Thus, at Blakeney there is a distinct zonation between the free-growing *Pelvetia*, which occupies the upper parts of the *Salicornia-Aster* marshes, and the embedded *Fucus vesiculosus* of the lower levels. Again, in the Blackwater marshes *Ascophyllum* ecad *scorpioides* occurs only in a narrow vertical range, commencing slightly below the upper limit of *Fucus vesiculosus* and extending a short distance downwards, but not nearly to the lower limit of that species.

It is noteworthy that the order of zoning is the same in both cases as that of the parent species on a sheltered rocky shore. (The relative vertical distribution of *Fucus vesiculosus* and *Ascophyllum* varies with the exposure (see Börgesen, 1908, p. 743)). This is shown in the diagram (fig. 14, p. 363), concocted from the data collected in various localities. On the salt marsh, however, the factor determining the vertical range of any species appears to be, not the time of immersion per tide, but the number of tides reaching any level. The duration of the long exposure over the neap tides, which may be curtailed by a whole day with the access of an extra tide, caused by a change in level of a few inches, is in this case the most important factor in determining the zonation.

Distribution of Marsh Fucoids in relation to the Salinity of the Water.

In cases of extreme dilution of the tidal waters, we get on the marsh, as on the seashore, a replacement of marsh *Fucus vesiculosus* and *Ascophyllum* by the marsh *Fucus ceranoides*. This is shown at Keyhaven. The only comment which is necessary in this connection is that, because of the retention of salts by the flat soil, the marsh *Fucus ceranoides* does not appear at such a high concentration of water as its rock analogue, so that the other marsh algæ hold their own up to a much greater dilution than they could under normal shore conditions.

Epiphytes and Undergrowth subsidiary to the Fucoid Undergrowth.

The undergrowth of brown algæ is not generally by any means a pure formation. Very frequently it is accompanied by a ground flora. The persistence of this ground flora is a measure of the density of the algal matrix, and it is a noteworthy fact, that under *Pelvetia canaliculata* ecad *libera* the ground flora is completely absent. The usual species represented are those which normally comprise the undergrowth of salt marshes:—*Catanella Opuntia* is very common and also a small peculiarly curled variety of *Enteromorpha intestinalis,* which grows loose among the Fucus in the Blackwater marshes. Besides these the filamentous green algæ, and especially *Rhizoclonium riparium*, persist as a covering to the marsh and under the brown algæ.

The epiphytic vegetation is often quite luxuriant. It is interesting to find that *Ascophyllum* retains its epiphytic *Polysiphonia fastigiata* on the salt marsh. Also that *Polysiphonia violacea*, various *Chætomorpha* species, *Catanella Opuntia*, *Rhizoclonium riparium*, and the characteristic salt-marsh alga, *Bostrychia scorpioides*, are all frequent as epiphytes, especially with *Fucus* and *Ascophyllum*.

Other epiphytes, encouraged no doubt by the humid conditions of the marsh, are very common—various species of *Ectocarpus*, *Oncobrysa adriatica*, and other small gelatinous algæ frequently enveloping the fronds of the thallus. These are found on *Pelvetia* as well as upon *Fucus* and *Ascophyllum*.

We have not worked out this epiphytic and undergrowth vegetation in detail, but the general report on the Marine Algæ of Blakeney Point, now in course of preparation by Mr. A. D. Cotton, will contain specific information regarding that area.

The Fuci are not without endophytes: fungal hyphæ are often to be seen in microscopic preparations, especially of the marsh *Pelvetia*; *Mycosphærella Pelvetiæ*, Suth., is apparently constantly present (see Sutherland, in the 'New Phytologist,' xiv. (1915), p. 34), and other species are frequent, as the same author as shown in subsequent papers.

Besides this, the dense undergrowth of algæ, especially the *Pelvetia* at Blakeney Point, forms excellent cover for innumerable small crabs, shellfish, and other animals.

(c) *Brown Algæ as a covering Vegetation after Erosion.*

A bank of sand or mud, which is undergoing erosion, presents a vertical or concave face to the current, in contradistinction to an accumulating bank, which usually shows a broadly convex surface. This is of course due to the fact that the only effective mode of attack upon a vegetation-covered surface by the sea is the method of undercutting. The result of this, at the edges of marshes or streams, is the formation of cliff-faces, which are vertical or concave in contour. On these vertical banks the conditions are obviously quite different from those obtaining on the flat plains of the marsh proper, and they have, in consequence, a peculiar vegetation, a fact which was first recognised and described by Cotton (Clare Island Survey, p. 82).

Mud cliffs of this type are frequent in the Blackwater marshes, and, wherever they occur, *Fucus spiralis* v. *nana* becomes the characteristic vegetation. On the banks which fringe the great tidal channels of the marshes the *Fucus* may occur in practically pure formation, covering the whole cliff-face, more or less sparsely; but, so soon as the bank becomes sheltered from the swifter currents, by a bend in the cliff or the insertion of a small creek, a vegetation of filamentous algæ occurs, which is distributed in fairly definite vertical bands, analogous to the associations described by Cotton (*l. c.* p. 83) from the Irish peat marshes.

The commonest constituents of these were in the Blackwater marshes :—

Uppermost Zone	*Vaucheria Thuretii.*
Middle Zone	*Rhizoclonium riparium*
with	*Enteromorpha* (*percursa*?),
	Lyngbya ferruginea,
and occasionally	*Polysiphonia urceolata.*
Lowest Zone	*Enteromorpha* (*compressa*? and *percursa*?).

Where the filamentous algæ predominated *Fucus spiralis* v. *nana* only appeared at the lower levels of the banks, especially with *Rhizoclonium* and *Enteromorpha*, and did not extend over the whole bank, as it did in more exposed places.

It seems very doubtful whether the *Fucus* itself is of great value in preventing further erosion, as its habit is not well adapted to bind the soil, and the plants are usually rather distantly placed with their attachment-discs only just below the surface of the soil.

However, the plant is very tolerant of upheaval, and continues to flourish on pieces of mud which have broken away from the upper parts of the cliff-face and settled down as hummocks at the foot of the cliff. It may be that the very tenacious attachment-bases of the *Fucus* prevent further

2 D 2

disintegration of these hummocks, and not infrequently their flat upper surfaces become infected with the spiral *Fucus vesiculosus* from the marsh, Salicornias and Asters may follow this, and so the hummocks may be gradually raised again to the level of the marsh.

General Summary.

The origin of the Fucaceous vegetation, which is often a conspicuous component of the salt-marsh flora, is primevally the attached Fucaceous association of the rocky shore. The production of a salt-marsh variety from a saxicolous plant may be brought about in two ways: either by direct vegetative budding from detached fragments of the thallus, or by the modification of young plants germinating upon a salt marsh. Each individual species undergoes a series of striking morphological modifications in the transition from rock to salt marsh, and the adaptational varieties so produced are designated "ecads," according to the nomenclature introduced by Clements in 1905; they are persistent through many vegetative generations. When the modifications were critically examined, it was found that, in all the five species represented on the salt marsh, the modifications induced by the new conditions were of the same general type. Hence the several marsh ecads produced by each species were grouped together under a "megecad *limicola*," which included all the marsh-dwelling Fucoids as distinguished from those of saxicolous habit.

The characteristics of the "megecad *limicola*" are, briefly:—

1. Vegetative Reproduction.
2. Dwarf Habit.
3. Absence of Attachment Disc.

And in the salt-marsh formation, but not in the loose-lying formation:

4. Spirality or curling of the thallus.

Of the seven species of Fucaceæ occurring in the littoral region of the English coast, four—namely, *Pelvetia canaliculata*, *Ascophyllum nodosum*, *Fucus vesiculosus*, and *Fucus ceranoides*—form varieties which may be classified under the megecad *limicola*. *Fucus spiralis* is only represented on the marsh by its variety *nana*, which cannot be regarded as a true salt-marsh variety. It was shown that all the dwarf spiral forms of *Fucus* as well as the turf-like and filiform Fuci, occurring on our salt marshes, are referable to the megecad *limicola* of *Fucus vesiculosus*. These very dwarf forms are parallel to, but not identical with, the three dwarf forms of *Fucus vesiculosus* found in the loose-lying formation of the Baltic—ecad *nanus*, ecad *subecostatus*, and ecad *filiformis*. To avoid confusion, a new name,

ecad *cæspitosus*, was therefore suggested for the dwarf turf-like form, commonly known as *Fucus balticus*; while for the other marsh forms of *F. vesiculosus*, the names ecad *volubilis* and ecad *muscoides* were retained.

A detailed study has been made of the connection between the novel physical factors, operating in the salt-marsh habitat, and the morphological modifications, characteristic of that environment. Two general methods have been employed in this investigation :—

(1) An examination of the distribution of the natural varieties of a single salt-marsh species, from which the effect of variations in certain physical factors upon that species has been deduced.

(2) A critical examination of the conditions under which exceptional forms may be produced which do not show the usual salt-marsh modifications.

By the combination of these two methods a certain amount of evidence has been brought forward, correlating the morphology of these forms with their new environment. The results may be stated in epitome.

Dwarf Habit is due to a change in the vertical position of the species relatively to the tide. This causes prolonged exposure, which produces a shortening of the thallus, together with a decreased access of nutrient salts, which produces a narrowing or attenuation of the thallus.

Curling or Spirality is probably due to an unequal distribution of water and nutrient salts upon the thallus, which is spread out over the mud in intertidal periods and inappreciably moved by the covering tides; but this quality is of great advantage to a marsh alga and may be promulgated by selection.

Vegetative Reproduction, or the replacement of vegetative budding for sexual reproduction, is probably favoured by the humidity, maintained over the marsh surface in the intertidal periods. This prevents the cell-sap from reaching a certain limiting concentration, which is necessary as a stimulus for the production of receptacles and, further, for the maturing of the sexual bodies. The subject is beset with many difficulties, not the least being that the formation of sexual organs appears to become habitual after a preliminary series of stimuli. The formation of vegetative buds may be favoured by the high humidity in the intertidal periods.

A consideration of the conditions operating in the loose-lying Fucaceous formations of the Baltic, showed that similar changes in morphology were induced by the same change in physical conditions, with this one difference, that the shortening of the thallus, associated on the salt marsh with the vague term "exposure," is referable, in the loose-lying formations, to a decrease in the photosynthetic activities of the *Fuci*, caused by diminution in light and CO_2 access.

An examination of the morphology of the famous floating Sargasso weed revealed the interesting fact, that its peculiarities could be referred to the

same physical factors as those of the marsh Fucoids—a confirmation of Börgesen's contention that it is produced and reproduced vegetatively from one of the saxicolous Sargassums.

The Fucaceæ may play an important part in the economy of a salt marsh. They may come in as pioneer vegetation after the ground has been raised, and to some extent stabilised by filamentous green algæ. The true halophytes follow very closely upon the pioneer *Fucus*, and, after they have colonised the ground, the algæ persist as an undergrowth, forming an efficient protection for seedling halophytes, as well as a ground mulch for the adult plants. In connexion with this undergrowth there may be a ground flora, as well as a considerable epiphytic vegetation. One species, *Fucus spiralis* v. *nana*, is a characteristic colonist of the vertical or concave mud-banks caused by erosion, and may afford some check to further erosion.

The zonal distribution of the Fucaceæ, at definite vertical levels, is maintained upon the salt marsh; the order of zoning remaining the same, for any two species, as that of a sheltered coast. But here the determining factor is not the time of immersion per tide, but the number of tides covering any particular level of the marsh.

It is impossible to conclude a study of this kind without emphasising the need for more definite information about the physiology of the higher algæ. The thallus of these plants is so plastic, that it responds to every change in environment with an almost machine-like regularity, and yet we are so ignorant of its physiological methods, that we cannot give reasons for even the simplest of our observations. How can one estimate the effect of exposure, without knowing whether the plant can carry on photosynthesis in humid air? What significance is there in determining the distribution of cryptostomata without any knowledge of their function? There are, no doubt, great difficulties in the handling of the Fucaceæ in a physiological laboratory; but we commend the matter to the attention of seaside physiologists.

Finally, we must acknowledge our obligation to the many friends who have assisted us both in the field-work and in the more critical part of this investigation. Our thanks are especially due to Mr. A. D. Cotton, of the Herbarium, Royal Gardens, Kew, whose expert advice has been most valuable in unravelling our systematic problems; also to Miss Ellen Kucewicz, who construed for us the main portions of Arcichovskij's lengthy Russian paper on degeneration in *Fucus*, and to Professor F. W. Oliver, under whose general direction the research has been carried out.

The investigation was indebted to assistance given by the Percy Sladen Trust in so far as the work is based on observations at Blakeney Point.

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EXPLANATION OF THE PLATES.

PLATE 28.

Mud-bank colonised by *Fucus vesiculosus* megecad *limicola* being invaded by *Salicornia* and *Aster.* Mersea Island, Essex.

PLATE 29.

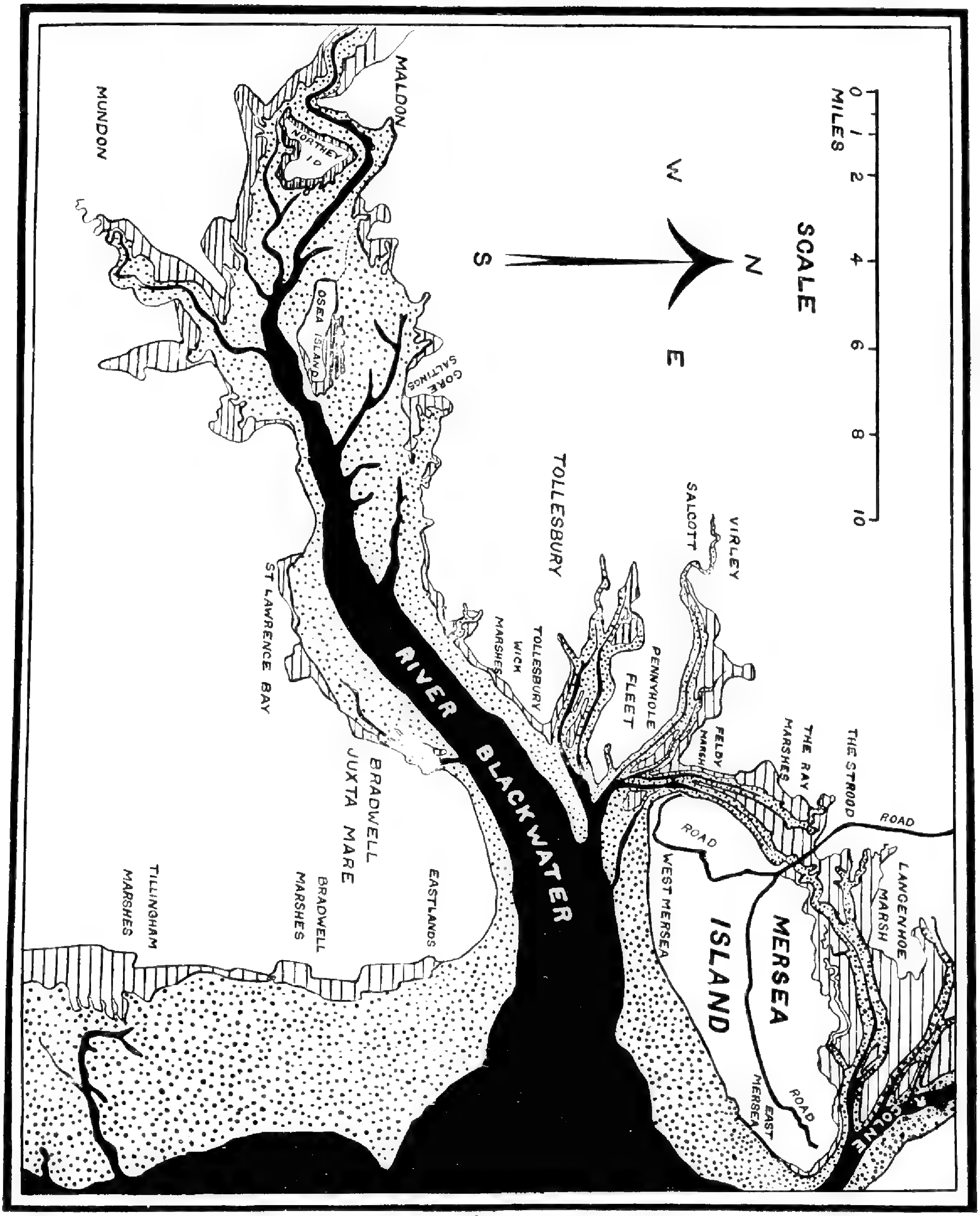
Undergrowth of *Ascophyllum nodosum* ecad *scorpioides* and *Fucus vesiculosus* ecad *volubilis* with *Aster.* Osea Island, Essex.

PLATE 30.

MAP showing the River Blackwater and tidal boundaries.
Salt marshes in line-shading; mud, dotted.

PIONEER *FUCUS*. MERSEA ISLAND.

ASCOPHYLLUM UNDERGROWTH, OSEA ISLAND.


SCALE
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MALDON
MUNDON
NORTHEY I.D
OSEA ISLAND
GORE SALTINGS
TOLLESBURY
SALCOTT
VIRLEY
ST LAWRENCE BAY
TOLLESBURY WICK MARSHES
PENNYHOLE FLEET
FELDY MARSH
THE RAY MARSHES
THE STROOD
ROAD
RIVER BLACKWATER
BRADWELL JUXTA MARE
EASTLANDS
BRADWELL MARSHES
TILLINGHAM MARSHES
WEST MERSEA
MERSEA ISLAND
EAST MERSEA
LANGENHOE MARSH
COLNE

M. H. B. del.

Short Cuts by Birds to Nectaries.

By C. F. M. Swynnerton, F.L.S., F.E.S., C.M.B.O.U.

(Plates 31 & 32.)

[Read 5th March, 1914.]

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A. Introduction.

1. Before going on to state the observations that form the subject of this paper, I would like to take this, my first public opportunity, to tender my very warm thanks to the staff of the British Museum Herbarium—my kind friends Dr. A. B. Rendle, Mr. E. G. Baker, Mr. Spencer Moore, and Mr. A. Gepp—for the immense trouble they expended over the working out of my plant collection. The value of help of this kind and the very real incentive it supplies to extended and possibly useful work can only, I think, be fully appreciated by those who have for some years struggled along with but a hazy knowledge of the nomenclature and affinities of the objects that have excited their interest.

I have, however, to thank them for much more than this: Mr. Moore has never tired of urging me to take up pollination and ecology, and has assisted me on various points in connection with the present paper; and to him, to Mr. Baker, and to Dr. Rendle I am indebted for much kindness and help of various kinds during and since my last visit to England.

I would also like to acknowledge my indebtedness to my very kind and deeply-regretted friend, the late Miss Helen Robins, for the great trouble she went to in typing a large portion of this and other papers for me from a very illegible MS.; as well as to Dr. Daydon Jackson, for much help in

ascertaining what has already been written on the subject of ornithophily in flowers; and to Mr. W. R. Ogilvie-Grant, Mr. H. Grönvold, and Mr. G. B. Lodge, for their kind and useful suggestions with regard to the sunbirds roughly outlined in Plates **31** and **32**. Finally, it is probable that these notes would not have been published at all had it not been for Professor Poulton.

2. *Some previous observations.*—Dr. Paul Knuth, in his excellent 'Handbook of Flower-Pollination,' gives a *résumé*, with lists, of such observations on ornithophilous flowers as had been recorded up to 1897, and refers to a perhaps fuller account of the subject (E. Löw, "Ueber Ornithophilie Blüthen," in Festschrift zur 150 jährigen Bestehen des Kgl. Realgymnasiums, 1897, pp. 51–61), which I have unfortunately so far been unable to procure.

I extract the following passages from Mr. J. R. Ainsworth Davies's translation of Dr. Knuth's account of the subject (pp. 73–77):—

α. "Humming-birds and honey-birds . . . . are not the chief or exclusive agents of cross-pollination in many flowers. According to the reports of Fritz Müller to his brother Hermann (Schenk's 'Handbuch der Botanik,' i. p. 17), there are also larger birds that do this—the large flowers of *Carolinea*, with their immensely long filaments, are not pollinated by humming-birds, which are much too small, but by woodpeckers and other relatively large forms. Hermann Müller further remarks (*op. cit.*): 'Woodpeckers may seek in the flowers for insects as well as honey, but certainly for the latter.'"

It will be seen that the equivalent statement is also true of African birds. Sunbirds and honey-birds are by no means the exclusive agents of pollination there.

β. Fritz Müller, writing to F. Ludwig (Bot. Centralbl. lxxi. 1897, pp. 301–302) on humming-birds, says: "I could almost believe that the list of flowers not visited by them would be considerably smaller than a list of those that are visited. . . . In the winter months when butterflies and bees are very rare . . . . these birds are almost the only flower visitors."

At any rate, the first part of this statement is to a large extent true also of sunbirds in Africa.

γ. Fritz Müller goes on to say: "Frequently (like the largest of our bees, a *Xylocopa*) they steal the nectar by boring, *e. g.* in *Abutilon* and the beautiful *Jacaranda* (*digitaliflora*?)." In Europe sparrows break crocuses and bullfinches primroses, for the nectar. In Africa, too, both sunbirds and *Xylocopa* "steal the nectar by boring." I have not myself seen the carpenter-bees doing this, but my friend Mr. G. A. K. Marshall tells me that he has very frequently watched them slitting the flower-bases. In birds, apart from what I have seen myself, I have just come across the following statement in Capt. Shelley's 'Birds of Africa,' ii. p. 90:—"Dr. P. Rendall, in his recent notes on the ornithology of the Gambia, remarks: 'Scarcely a flowering shrub in my garden yielded any flowers the corollas

of which had not been pierced by individuals of this species' [*Chalcomitra senegalensis*, (Linn.) Shelley] 'or of *Cinnyris cupreus*,' (Shaw) Shelley ['Ibis,' 1892, p. 219].'"

My own observations were all carried out many months before I had an opportunity of reading of the work of others on the subject, and now that I come to do so, it is interesting to me to find that what I have seen occurring in South-East Africa also occurs in other parts of the world. It encourages me to believe that the instances of *discriminative* damage and discriminative *utilization* of damage that I shall describe are likewise perhaps by no means isolated.

3. *The present observations.*—I had carried out my earlier observations on *Canna indica*, and was actually engaged on my resulting investigation of *Leonotis mollissima* and *Erythrina Humeana*, when Professor Poulton, ever helpful and stimulating, presented me with a copy of Thomas Belt's fascinating 'Naturalist in Nicaragua.' This—and especially Belt's application to the thickened calyx of a Nicaraguan *Erythrina* of the explanation (though in reference to insect attacks) that my observation of the actual results of *bird* attacks had already suggested to me for certain features of *Erythrina Humeana* and the *Leonotis*—naturally whetted my interest greatly, and I subsequently carried out the majority of the observations that I now propose to record. They are still far too scanty and incomplete, but Professor Poulton has been kind enough to urge that they may nevertheless be worth publishing. All were carried out in the neighbourhood of the Chirinda Forest in the Melsetter district of Southern Rhodesia.

I have found a roughly chronological order the most convenient, but the plants and birds observed have been stated in systematic order in the final lists.

B. Observations on *Canna indica*, Linn., var. *orientalis*, Rosc., and other Species.

The following was my first actual note on the subject of this paper :—

"June 25th, 1911. I have several times in the past few months noticed small sunbirds probing the bases of *Canna* flowers in the garden, evidently through an artificially made opening. A little female *Cinnyris chalybæus*, (Linn.) Shelley, has been doing it a good deal during the last three or four days, and to-day after her departure I went down and examined seven flowers, each of which I had watched her probe in this way. One had two small holes and each of the others one, all in more or less the same position, namely just above the outer whorl of the perianth and through the base of one of the inner segments. Only one of the eight was a perfectly fresh puncture, the edges of the remainder being already more or less dry and brown. Evidently an old hole had been utilised wherever it existed.

"On the outside of some of the flowers thus probed (but not of all) were small green aphides, but I had been near enough to the bird to be able to judge quite definitely from its actions that it was not these that it was taking. The point of the bill had in every case been applied in a decided and unhesitating manner to a single point in the base of the flower and been pressed well in, the flower sometimes quivering with the pressure. I examined many other Cannas, and found that in not less than one in three the same small hole was present. In two cases its place had been badly chosen, immediately above the ovaries, and therefore just too low for the bird's purpose ; but in neither of these had the bill penetrated deeply. Such flowers as I opened contained no insects, and there was nothing to indicate that the holes had been made by any agency other than the bird's bill."

"I have frequently, since making the above note, watched the sunbirds utilising or making such holes : on a few occasions when I have noted the exact spot at which the bill was inserted and gone to inspect, I have found a wet, glistening, obviously freshly-made hole. It has usually been near the point of the angle formed by two segments of the outer whorl. I have also, as in the above observation, broken up many such flowers without finding a trace of any insects inside, nor have the holes seemed to me such as might have been made by any of our usual honey-eating insects, unless by *Xylocopa*, and I have not seen this at the flowers. There has been throughout a fairly marked difference between individual birds in this matter of proneness to take short cuts : thus on August 6th (1911) I noticed that of a male and two female *Cinnyris chalybæus* that I watched simultaneously at the Cannas for about ten minutes, one female never used the flower's natural opening, while the other seldom failed to, and the male used sometimes the one and sometimes the other. I am unable to say at the moment which mode of entering the flowers is the most used. I have in a few cases seen indirect evidence of a *failure* to pierce."

The above passage was probably written in July or August, 1912, when, at Professor Poulton's suggestion, I commenced to shape my notes into a paper for publication.

"May 15th, 1913. The *Canna* bed has been popular of late, and on examining to-day the bases of a large number of flowers of five varieties, I found that nearly all of them had been pierced in the manner described already."

"May 20th, 1913. Watched a female *C. chalybæus* enter two, I think three, flowers of (A), a *Canna* sp. with small orange-yellow flowers that had grown out far from its original spathe, all by previously made artificial openings, then go on to another (B) (*Canna indica*, Linn., var. *orientalis*, Rosc.), the flowers of which were closely backed by the spathe. Here she probed three flowers, all by their natural openings, using the spathe as perch. I at once drew both plants (Pl. **31**. fig. 1), and a reference to the figures

will make things clearer. Curiously two of the three flowers on B possessed sunbird punctures at their base, but these were ignored in favour of the easily reached natural opening—tending to show that even if some birds tend to pierce indiscriminately, those that follow them may discriminate.

"It struck me to ascertain whether basal flowers, still capable of being reached from the spathe, suffer in general as much piercing as the more terminal ones. I first took the variety (*Canna indica* var. *orientalis*) to which B belongs. I could find only twelve flowers of the first kind. Of these, 6 were pierced, 6 not. Of 30 more terminal flowers 18 were pierced, 12 not. In 64 non-basal flowers of two other varieties or species (large orange-copper with bronze leaves, and small yellow like A referred to above) 54 were pierced, 10 not ('copper' 20 : 2, small yellow 38 : 8). No basal flowers were available for these species."

"June 2nd. Saw a male *C. chalybæus* enter wrongly even three or four flowers, more or less sheathed, of *Canna indica* var. *orientalis* (=B) as well as one standing well out. A female shortly followed. She visited the same flowers, the more or less sheathed ones by their natural openings—not all of them *very* easy—and the one that was more inaccessible by the opening made and used by the male."

I have frequently noticed in these Cannas that, as a rule, the fruits are massed at their bases, the terminal portion of the axis being bare. Discriminative action of the kind just described might produce such a result, for it is the basal flowers that are usually in this species the easiest of entry by the natural opening. On the other hand, a capacity to carry only a limited number of fruits, such as probably exists, would alone sufficiently account for the terminal bareness in cases in which the basal flowers had been successful.

Summary :—

1. Sunbirds (*C. chalybæus*) were actually seen, on many occasions, making short cuts to the nectaries of *Canna indica*, var. *orientalis*, Rosc. (and other species) or utilizing previously-made short cuts, and thus evading the duty of pollination.

2. Individual birds varied. Some were probably nearly, or quite, indiscriminating; they seldom used the flower's natural opening, even when this was easy of access. Others were discriminating, utilizing the artificial openings only when the natural ones were somewhat inconvenient.

C. Observations on *Aloë Swynnertonii*, Rendle.

Subsequently to the above observations a low aloe with several flowering branches, growing beside the house, was in bloom for nearly a month. Close to it were three tall *Canna* plants of B variety. A pair of sunbirds (*C. chalybæus*) used to visit both daily. I occasionally watched the birds,

and saw them treat the Cannas as already described, but always enter the aloes properly. I also examined all the flowers both of this aloe and of the Cannas on not less than eight separate occasions during the month, each time just after the birds had visited them. On no occasion did I discover a damaged aloe blossom: on every occasion a greater or smaller proportion of *Canna* flowers had been pierced. The aloe flowers were not always conveniently situated—never, I should say, *very* conveniently, for the bird had at all times to lean out to reach them—but their very thin and very pliable pedicels made them so unstable that a sunbird would, I think, have found it very hard indeed to *pierce* them, however possible it might have been to bite a piece out of them. At the same time this pliability made it easy for the sunbird to pull them round to itself after inserting the point of its long, curved bill in the mouth of the perianth.

D. Observations on *Gardenia tigrina*, Welw., and *Dracæna fragrans*, Gawl.

I have on several occasions watched the bases of flowers of *Dracæna fragrans* and *Gardenia tigrina* being pierced in exactly the same way. The *Dracæna* is one of the commonest shrubs in the Chirinda Forest, and the culprit has been in each case *Cinnyris olivacina* (Peters) Gadow. The *Gardenia*, also common, is one of our larger forest-trees, but my direct observations on it in this particular connection were carried out almost entirely on a young tree, 11 feet in height, that stands on my lawn. I have seen the bases of its corolla-tubes punctured by both *Cinnyris chalybæus*, Shelley, and *Cinnyris venustus* (Shaw) Shelley, var. *niassæ*, Reichw., few, if any, of the flowers on the tree escaping, and I do not now remember having ever seen them entered by the natural opening. Indirect evidence was afforded by similarly pierced fallen corollas that I have sometimes picked up in the forest. I have failed to find evidence of *un*successful attempts to pierce.

In the *Gardenia*, improperly entered by *all* individuals, the incentive to the robbery was probably to be found in the fact that the natural opening of the flower was high and inverted and, unless the bird should hover, was much harder to reach than the base was to pierce. The large, rather tiger-lily-like flowers are perched in a vertical position at intervals along the upper surface of the more or less horizontal twigs, and it must be quite difficult for a small sunbird to reach over and down to the honey-glands. This explanation will hardly by itself account adequately for some of the *Canna* instances.

It seemed in any case unlikely that these attacks would tend to any great extent to hinder pollination in the *Dracæna* and *Gardenia*: both are markedly entomophilous, and the punctures I have seen the birds make in their flowers probably constituted no great injury to them, seeing that they were usually

by no means of a kind to admit the insects on which these species apparently mainly depend *.

But the question naturally suggested itself: How are very definitely *ornithophilous* flowers, to whose chances of cross pollination such openings might often be fatal, guarded (if at all) against such attempts? This led to observations on *Erythrina*, *Leonotis*, and *Grevillea*.

E. Note on *Erythrina*.

My observations on two Erythrinas (*E. Humeana*, Spreng., and *E. tomentosa*, R. Br.) cover slightly wider ground than my remaining observations on ornithophilous flowers. I have accordingly, with some reluctance, decided to hold them over for later publication in another connection.

I will merely state here that in their case the damage (less often successful than in, e. g., *Canna indica* or *Gardenia tigrina*) was inflicted not only by sunbirds but by widow-birds too (*Coliopasser ardens*, Bodd.), and that here again certain individual birds damaged more or less indiscriminately while others, that followed, utilized the damage whenever the flower's natural opening was inconvenient.

An attempt was made to ascertain whether discrimination on the part of the birds resulted in a correspondingly discriminative setting of fruit. Complicating factors, as the destruction of many of the young fruits by moth-larvæ and probable incapacity of a peduncle to carry more than a limited number of fruits (the capacity varying apparently with soil, &c.), obscured the result; but a clear instance of elimination was seen in each of two groups of trees (both *Erythrina tomentosa*) no less than 20 miles apart. In one tree in each group the next-to-open buds overhung the open flowers, obstructing the operations of the more indiscriminate birds. In the other trees of each group they tended, as is the more usual at Chirinda, to turn back. Many of the overhanging buds were torn bodily off, while those that turned back were spared.

The birds watched visiting the flowers of *Erythrina Humeana*, Spreng., were a Ploceid (*Hyphantornis jamesoni*, Sharpe), a white-eye (*Zosterops anderssoni*, Shelley), three sunbirds (*Cinnyris venustus* var. *niassæ*, Reichw., *Chalcomitra gutturalis* (Linn.) Cab., and *Chalcomitra kirki*, Shelley), a bulbul (*Pycnonotus layardi*, Gurney), and a coly (*Colius striatus* var. *minor*, Cab.).

The birds watched visiting the flowers of *Erythrina tomentosa*, R. Br. were five Ploceids (*Sitagra ocularia*, A. Sm., *Hyphantornis jamesoni*, Sharpe, *Coliopasser ardens*, Bodd., *Estrilda astrilda* (Linn.) Swains., and *Estrilda kilimensis*,

* I have, however, since writing this come across some instances of far severer damage in the Chirinda Forest, the bill-marks suggesting that the forest bulbuls (*Phyllostrophus milanjensis*, Shelley, and *Phyllostrophus flavistriatus*, Sharpe) may have been the culprits.

Shelley), four sunbirds (*Nectarinia arturi*, P. L. Scl., *Cinnyris chalybæus*, Shelley, *Cinnyris leucogaster*, Vieill., and *Cyanomitra kirki*, Shelley), a bulbul (*Pycnonotus layardi*, Gurney), and two warblers (*Prinia mystacea*, Rüpp., and *Sylvia simplex*, Lath.).

In *Erythrina* more strongly perhaps than in any other species came out the fact that whether a tree would be subjected to the infliction of short cuts (and consequent discriminative pollination by the subsequent utilizers of the short cuts) depended primarily on if it happened to be included for the time being in the "beat" of individual birds that specially resorted to such short cuts. Moreover, observations in two successive seasons on *E. Humeana* showed that exclusion of particular trees at one period is no guarantee that they have been, or will be, excluded permanently from the operation of such probably selective influences.

F. Observations on *Leonotis mollissima*, Gürke.

An erect herb growing often in masses in grass jungle such as occurs in glens and on the outskirts of forest. It is conspicuous by its height (as much as 8 or 9 feet) and by its bare upper stem, varied at the nodes after the manner of a poodle's legs with the large, nearly spherical verticillasters. Each of these is a ball, consisting of a closely-packed mass of (eventually in some cases up to three hundred, or even more) long spiny calyces, radiating from and concealing the twelve or fifteen sharply downturned flowering axes from which they spring. The latter nearly hug the stem and tend to turn in towards it below, at their growing point. Only at a single level (roughly speaking) will opened corollas usually be found at any one time. Above this row the calyces and their projecting spines are already becoming dry and stiff, and in the uppermost rows will even have ripened their seeds. Below, a few rows of yet undeveloped buds, and finally some down-pointing bracts, fill the space between the flowers that are out and the main axis of the plant, and complete the under surface of a spherical "*cheval de frise*" that must, one would suppose, act rather as a deterrent to would-be honey-robbers amongst, at any rate, the shorter-billed birds *.

The flowers are greatly visited by sunbirds, particularly, on the outskirts of the Chirinda Forest, by *Cinnyris olivacina*, Gadow. In the "Jihu," a large grass-jungled tract of the Portuguese East-African district of Mossurise, the *Leonotis* is immensely abundant, and during a stay there in 1906 I found the flowering verticillasters frequented greatly by bulbuls (*Pycnonotus*

* An entomophilous species, *Pycnostachys urticifolia*, Hook., has an elongated *cheval-de-frise* arrangement on a different plan, and is quite possibly thereby protected to some extent from illicit entry by the various species of *Xylocopa* and *Podalirius*, which seem to be its chief visitors at Chirinda.

layardi, Gurney), white-eyes (*Zosterops anderssoni*, Shelley), various sunbirds (especially *Cinnyris kirki*, Shelley), and other species. The honey appears to be the main attraction, at any rate, to the sunbirds, though the calyces are often inhabited by minute beetles and other insects, and these may quite likely serve as a strong attraction in themselves. I have several times seen a *Zosterops* draw two or three larvæ in succession from the *Leonotis* calyces, generally perching below and probing all round with its bill ('Ibis,' 1908, p. 46), but they are also great nectar-eaters.

The flowers, too, are commonly, but not always, probed by the sunbirds (and especially by *Cinnyris olivacina*) from below, the bird clinging to the square, deeply-ribbed, slightly "roughed" stem below the sphere, and probing each flower in turn till it has completed the round (*cf.* 'Ibis,' 1908, p. 42). Below verticillasters that have been long in use, the scanty, very short tomentum and the normally green outer cuticle sometimes become noticeably worn. The single row of flowers that is available at any one time is usually, following the growth of the flowering axis, fairly near the lower surface of the sphere, and the narrow, vaulted upper lip of each corolla projects well out horizontally or somewhat downward, roofing in the anthers and surrounding them with a fence of its stiff fringing hairs. The stamens and pistil project within it to approximately the same distance as itself—so far, that in the practical absence of the withered lower lip it is unlikely that the flower would frequently be fertilized by any but a hovering insect such as a Sphingid. I have twice, however, watched females of *Papilio dardanus*, Brown, feeding as usual quiveringly on tiptoe, keep brushing the anthers with their heads. Hive-bees that I have watched at the flowers' natural openings have not come in contact with the anthers at all, excepting when collecting pollen. The flower seems well adapted, however, to pollination by sunbirds perching below, and in this case it is the bird's forehead that does the work. The conveniences afforded by the relatively low position of the flower, its usually somewhat downward trend, and the absence (shared with *Erythrina*, though brought about differently) of any such obstacle as a strongly-marked lower lip to the inward push of the bird's throat, must all help to make the legitimate opening as it usually occurs a sufficiently easy one to a bird thus perching below.

The compactness of the flower-balls of the *Leonotis*, though probably advantageous in relation to birds, apparently lends itself to the purposes of an enemy. A weevil larva (and later, pupa) is often to be found ensconced in a large, smooth cavity hollowed out of the heart of the verticillaster and entailing the destruction of the bases of a number of the flowers ; it emerges in October and November. I have also found ants eating into the bases of some of the flowers.

One other point in connection with the *Leonotis* may be worth mentioning, though it is not strictly within the scope of this paper. It is that it requires

a moderately strong wind to spill the ripened seeds out of the often more or less upward-pointing calyces that contain them: and *Leonotis* frequently grows in situations that are sheltered from wind. But a bird, attracted by the flowers below and suddenly flying to them, is capable, by the swing it imparts to the vertical stem, of scattering the seeds. I have seen instances of this, and have verified it by experiment.

Damage by birds: The individual calyx at the flowering stage should not be difficult to pierce, and quite early in my investigation of the plant, as the result of examining a considerable number of the heads, I found many instances of successful piercing. It was always the typical sunbird puncture, and was probably the work of sunbirds, though, as Mr. Guy Marshall has suggested to me, it may not always be easy to distinguish this from the work of Xylocopid bees. In all these cases, however, the sphere was defective, leaving the bases of individual flowers exposed, and it was these flowers, and these only, that had been pierced—in every case on the exposed surface. I never in these earlier cases found an instance of such piercing where the flower-ball was normally compact and spherical, though I broke up and examined a large number. All were, however, within a single limited area. Later, a few hundred yards away on the outskirts of the Chirinda Forest, I obtained the following observations:—

"June 2nd, 1913. Watched for some time on the outskirts first *Anthothreptes hypodilus* (Jardine) Gadow, then *Cinnyris niassæ*, Reichw., both males, entering flowers of *Leonotis mollissima*—in practically every case from above. I was within two yards, the birds not seeing me. Mostly they perched above the flower-ball, in a few cases below, but they nearly always entered by an artificial opening in the side or roof of the flower. Very rarely the end of the corolla came against the bird's throat, even when, perched below, it was entering by an illicit opening; and here the stigma probably, and the anthers just possibly, may sometimes have come in contact with the bird. I took and examined two stems with twelve flower-balls, all of which I had watched the birds visit flower by flower. These showed 56 pierced flowers to 33 unpierced. In only one verticillaster was there a preponderance of unpierced flowers (6 : 5). In this one the flowering row was relatively (but not very) low in the ball, and therefore harder to reach from above. In some cases considerable force had appeared to be used, the bird going through the actual action of ripping; but for the most part previously-made openings, already with browning edges, were utilized. Where the calyx as well as the corolla was pierced, the slit in the corolla was nearer the base than the corresponding slit in the calyx. This was natural."

"June 3rd. Visited yesterday's *Leonotis* clumps. Fewer birds, but watched a female and later a male *Anthothreptes hypodilus* visiting the flowers. As yesterday, they perched mostly above and (to-day) invariably entered wrong. The male entered one many-flowered ball from below.

Even here he pushed himself well up, and at apparent *inconvenience* to himself—very distinctly greater inconvenience than the natural openings would have caused—entered by the slits above. I am inclined to conclude from this and many other observations, that it is not only the position of the flower that matters: there is also something *disliked*—perhaps the mere fact of getting dusted with pollen,—and apparently some birds object to this (or whatever it is that they dislike) more than others.

"I also watched, through my glasses, a hive-bee visiting in turn the bases, *above*, of many flowers in succession. The stem was inaccessible to me through the fact that it stood in a thicket of thorns, hence I was unable to examine the flowers; but I later noticed a bee settle, again *above*, on the other side of a flower-ball near me and remain there for some little time. Presently she worked round into sight, made a long stay at the base (above) of the first flower (A), evidently getting something, examined the bases of the next two (B and C) and passed on without appreciable delay, delayed not at all at the next (D), and only made the same delay at the last flower (E) that she had done at B and C. I examined. On the other side of the ball I found eight open flowers, of which five showed sunbird slits on their upper surface. A was similarly slit; B, C, and E were unslit; and D, though slit, was a dried-up but unfallen corolla of a day or two ago: I had not been able to detect this from where I stood. This bee—and the first one watched—had evidently been utilizing the sunbird slits and ignoring the flowers in which it failed to find them. Yet another hive-bee was collecting pollen, and visited only the ends of the flowers.

"In another ball on the same stem three of the flowers were cut off just in front of the calyx. It was possibly the work of birds, but less certainly so than yesterday's damage to *Kniphofia*.

"A larger proportion of unslit flowers was present to-day than yesterday—possibly the result of an apparent greater scarcity of sunbirds."

"June 6th. I passed a female *Anthothreptes hypodilus* visiting *Leonotis*. She flew away almost at once, but I first saw her visit two balls. One—she perched below it—was scantily flowered, and of the three flowers next to myself I saw her enter two by their natural openings, probably coming in contact with the anthers, &c., as she did so; the third by an artificial opening—by using which she definitely avoided touching the anthers. The difference between the flowers was marked as regards angle. The first two sloped straight outwards, the other away at an awkward angle.

"The second ball, a many-flowered one, she approached from *above*. She entered *all* its flowers (on the side that I could see) by previously-made artificial openings.

"I also saw a male of the same species visiting *Leonotis* flowers from *below*. The three or four verticillasters that I saw him probe had fairly regular flowers, and he entered many of these properly, but an occasional flower was

entered by an artificial opening. It was not a matter of the presence or absence of such openings, but *definitely* of his position relatively to the flower. A definitely inconvenient flower such as I had seen entered wrongly by the female would probably find few to enter it rightly, but naturally the bird's own position counts too. When this particular male perched close up to the flower-ball, or did not move round smartly in accommodation to the flowers, he entered even the most regular flowers wrongly.

"Later, evening. I ran over to Chipete (a small, 40-acre forest-patch crowning a hill a few hundred yards from Chirinda) . . . and . . . examined a large number of *Leonotis* heads thereabouts on a number of the plants in various places, and could only find two individual flowers that had even the corolla split."

On several other occasions, on which I omitted to take definite notes, I have stopped to examine roughly clumps of *Leonotis* that I was passing or to watch sunbirds visiting them. Only within the area on the forest outskirts that I have referred to did I find the large proportion of slit flowers described. Mostly I found none. From this I conclude that, as in the case of *Canna* and *Erythrina*, some individual birds are far more prone to slit than others, and that liability to slitting depends primarily on whether the individual plant happens to fall into the "beat," for the time being, of such a bird. Comparing species, I should say that *Anthothreptes hypodilus* and to a somewhat less extent *Cinnyris niassæ* have been more in the habit of perching above the flower-ball and of utilizing artificial openings generally than has *Cinnyris olivacina*. The latter species has mostly perched below the balls, and entered regularly all but irregular or otherwise inconvenient flowers, even where artificial openings were present.

I have also many times repeated my observation as to the dislike evinced by certain individual birds to the natural entrance. The bird has sometimes gone to a good deal of trouble to avoid it.

I have, further, repeated my observations on bees utilizing sunbird openings, and have watched a Lycænid (*Tarucus telicanus*, Lang) apparently doing the same thing.

Summary :—

1. Damage, and particular kinds of damage, was found confined to particular areas. This and direct observation showed that liability to damage—and to particular kinds of damage—depended in the *Leonotis*, as in *Erythrina*, &c., on the presence for the time being of individual birds with particular idiosyncracies.

2. As in *Canna*, apparently definite cases of the discriminative use of previously-made openings were seen, the natural opening being used where it was more convenient even with an artificial opening present.

3. In one area discriminative *damage* was seen, confined to flower-bases exposed by defects in the continuity of the flower-spheres.

4. There was evidence, in the shape of great trouble taken to avoid it, that certain individual birds more than others *disliked* the natural opening. This was probably largely responsible for the "short cuts" taken by the more indiscriminate individuals.

5. Hive-bees systematically utilized artificial openings, passing over the flowers in which they failed to find them.

G. Observations on *Grevillea*.

Grevillea robusta, A. Cunn., and *Grevillea Banksii*, R. Br., two flourishing importations from Australia, have been freely adopted by many of our local birds and each year ripen plenty of seed. My opportunities of observing the second-named species have not been so good as in the other case, but I have at one time or another seen its flowers visited by the following sunbirds :—*Chalcomitra kirki*, Shelley, *C. gutturalis* (Linn.) Cab., *Cinnyris chalybæus*, Shelley, *C. niassæ*, Reichw., *C. olivacina*, Gadow, and *Anthothreptes hypodilus*, Gadow. To these my friends Dr. and Mrs. W. L. Thompson, who have shrubs of this species in front of their house near Chirinda, add the malachite sunbird, *Nectarinia famosa* (Linn.) Shelley, and bulbuls, *Pycnonotus layardi*, Gurney.

The flowers of two large trees of *G. robusta* beside my house are continually visited not only by some of the above species of sunbirds but by two bulbuls (*Pycnonotus layardi*, Gurney, and *Phyllostrophus milanjensis*, Shelley), an oriole (*Oriolus larvatus*, Licht.), and a forest-hunting weaver (*Sycobrotus stictifrons*, Fischer & Reichw.). At "Wolverhampton" (a farm 20 miles from Chirinda) on Oct. 27th, 1912, I watched for some time at *Grevillea robusta* flowers two species of migrant warblers—a garden warbler (*Sylvia simplex*, Lath.), and a willow-wren (*Phylloscopus trochilus* (Linn.) Boie); also *Cinnyris niassæ*, *Pycnonotus layardi*, and *Hyphantornis jamesoni*, Sharpe.

A *P. layardi* that I shot after it had been busy for some time at my *Grevillea robusta* flowers at Chirinda had its forehead, lores, throat, and upper breast thickly besprinkled with pollen ; and these are the portions of their bodies which all the above birds, when I have watched them, appeared to rub against the upstanding pistils in reaching down to the honey. A captive bulbul which I provided with racemes of this species became most freely dusted immediately round the bill—that is, on the forehead, lores, and upper throat—but he also sometimes obtained pollen on the breast, as the result of leaning well over to reach flowers at a distance.

I have seen no honey-robbery by birds here, nor is there, I think, very much temptation or opportunity in relation to the birds I have actually seen at the flowers. The flowers generally are tough, lean and wiry—there is

really nothing to pierce—and the nectar lies quite open, a conspicuous, shining drop, backed with black, and welling up higher than the edges of its containing chalice. The only barrier to it consists (after the flowers are sprung) in the numbers of high, upstanding pistils, and not only are these extremely tough and pliable, bending easily beneath the bird's throat and at once springing up again when the pressure is removed, but an attempt to break or remove them on my part has almost always resulted in the whole flower coming away. A bite without a pull would be more effective, but I have witnessed no instance of it nor have I found amputated pistils in the very many racemes that I have specially examined. There are always numbers of individual fallen flowers beneath the tree. Here, again, out of over a hundred closely examined, only one bore a mark that could possibly be attributed to the pressure of a bird's bill, and it was probably significant that nearly all had already, before falling apparently, lost their perianth segments. My captive bulbul has never attempted damage nor appeared to be in the least inconvenienced by the erect pistils. A few unsprung flowers also fall. The birds perch freely on their down-bent pistils in order to reach the more inaccessible flowers, and this may, I suppose, result sometimes in such breakages. But their toughness and "spring" seem to fit them excellently to resist even this kind of pressure, and I have not found any trace of damage either in mature or immature racemes that I have examined after I had seen them trampled over by my captive *Pycnonotus layardi*. All the flowers had sprung back intact to their normal position.

Grevillea Banksii seems possibly to invite damage to a greater extent with its fleshier honey-cups and the difficulty that our sunbirds, up to *Cinnyris chalybæus* in size, experience in some of the racemes in reaching the uppermost flowers. I have occasionally seen narrow vertical slits in these that may or may not have been the work of sunbirds. The bird usually perches on the main peduncle below the flowers, and draws down slightly with the point of his bill each of the latter that he can reach. In doing this he appears often to press with his throat and breast such pistils below the flower visited as have already been released, and would probably often be bespattered in the same regions by any that he might release himself. Especially where the pistils hang well out and down he must also receive some of the stigmas on the forehead and crown, including probably that of the flower he is probing.

Arrived as high as he can reach, he has, in the relatively few instances that I have watched at all carefully, either gone on to the next spike or taken the upper flowers, hovering. Mrs. Thompson confirms this observation, and I have other observations that contradict what is, I believe, a somewhat general supposition—that sunbirds do not hover: not that they have done so at flowers at all *frequently* in my experience—though, from what Mr. W. L. Sclater tells me, my experience in this respect is somewhat different from his at the Cape.

A quite sufficient reason for the upward-pointing direction of the flowers of these Grevilleas is probably to be found in the fact that were they to point otherwise the honey would spill. This factor is not so greatly present in *Erythrina* with its more or less closed "honey-box," and is probably quite sufficient to account for the fact that *Grevillea Banksii*, unlike most of the other ornithophilous species of this paper, points its flower-openings away from the direction from which its birds arrive. Nevertheless, tilted well outwards, an open cup full to the brim and without intervening obstacles, the majority of them offer no greater difficulty than do those of the other species.

H. Observations on *Kniphofia rhodesiana*, Rendle.

This, our common "red-hot poker plant," is exceedingly conspicuous when in flower, with its bare smooth stems and long conical flame-coloured tops of buds, the lower rows only of which are open. It sometimes occurs in hundreds on a single hillside, when it affords quite a striking spectacle. The stem is smooth, yet soft enough to yield slightly to pressure, so that it probably affords some slight "grip" in itself to the birds which perch on it when the lowest flowers of the raceme * commence to open. They leave their claw-marks on it. Triangular bracts are also present, however, scattered over the surface of the stem for a short distance immediately below the flower-head, and, as I have actually seen, these must also be quite a help to the birds in the raceme's early stages. Later, the first flowers to open are hanging fairly flat against the stem, the perianths withered but still firmly attached, and they form a dense, firm, brown mat growing longer and longer as fresh rows of buds open and wither. It must afford a magnificent foothold to the birds. Immediately above this mat are the flowers, already trampled and bruised but still juicy, that will be the next to be added to it, and these in turn, packed densely, serve to support and so "give angle" to their newly-open neighbours higher up. These once more are usually packed close, like cells in a honeycomb, each protecting the next and protected from above by unopened buds. A dense mass of stamens projects downwards from them all round, making it impossible for a bird to enter a flower without coming into contact with many pollen-filled anthers. The honey is very abundant. Slits, above, below, or at the sides, but more commonly, I think, below, are present in a larger or a smaller proportion of the perianths in nearly every head. Where the flowers are closely packed in their normal manner, these slits would certainly prove no hindrance to pollination, nor, without examination, would they often be seen, far less utilized, by the visiting birds.

* "Spike" might seem at first sight the better term, but the flowers are not sessile in this species although "pedicellis brevissimis" (Journ. Linn. Soc., Bot. xl. (1911) p. 214).

Occasionally "faults" are present in a raceme—flowers twisted or unsymmetrically placed or over-scanty in some particular part. In these cases they themselves or their neighbours are usually more or less exposed, and slits or punctures in their exposed surfaces would often enable birds to extract the honey without coming into contact with the anthers and stigma.

There are two main varieties of the plant at Chirinda—one with the perianth-segments well marked and commonly slightly splayed back, the other with these parts quite small and inconspicuous and in practically the same plane as the rest of the perianth. The former flowers are usually (not always) the larger and are very commonly rather less densely packed. In each variety there is a little further variation in the matter of the diameter of the perianths. Sometimes the flowers of a raceme are characterized by a much-constricted neck as in some heaths.

"June 1st, 1913. Examined a few *Kniphofia* heads on the western outskirts of the Chirinda Forest. A very few split flowers were present, the slits probably not prejudicial to pollination. Abundant honey was welling forward in the tubes.

"June 2nd. Examined two heads standing close together on the northern outskirts of the Chirinda Forest. Some of the lowest flowers showed damage, and all the open flowers on one side of the head were broken off to at least half their length. The nature of the laceration and the fragments lying below indicated that it was the work of a bird, as did claw-marks on the stem and *very* definite bill-marks on some of the flowers. Impatience with the dense array of downward-pointing stamens struck me as a possible reason for this wholesale damage.

"Later I examined several heads above the dam. Very few were slit above, and these solely amongst the flowers that were already beginning to lie down fairly low, just above the mat—the work perhaps of claws. A few were slit on their under surface."

"June 3rd. Watched in turn, for quite a long time, two bulbuls (*Pycnonotus layardi*, Gurney) at the flowers above the dam in the early morning. They always perched below the flowers, one foot well above the other and on the mat. If the mat was already extensive both feet were on it, otherwise the lower foot was amongst the triangular bracts that sparsely cover the upper end of the bare stem. The birds probed the flowers in a fairly leisurely way one after the other until the round was completed, when they would fly on to the next head. No attempt at breakage was seen, and whenever the bird's face was not in shadow the light appearance of the parts immediately round the bill showed that these must have been well dusted with pollen.

"I saw two sunbirds—♂ and ♀ *Cinnyris chalybæus*—visit them too, and watched the female, which was nearer. She probed the lower flowers of each

head and did not seem, so far as I saw, to go as high as the bulbul: she seemed to avoid plunging right in amongst the pollen-covered anthers. I saw no recognizable instance of splitting. On visiting her flowers and those of her mate, I found the underside of a number of the lower flowers slit, but the majority of the slits were not, I judged, fresh. The slits might well, in some cases, have been made accidentally by a curved bill in emerging.

"There were a few hive-bees at the flowers. I watched three in particular. One was collecting pollen—she was carrying the usual masses of it. The other two were definitely trying for honey. They never went further in than the mouth of the flower, but in many cases a little honey was present there, having rolled out from inside. Pollen-eating flies were present and at work."

"June 3rd, 1913. P.M. Visited the two *Kniphofia* plants near Chipete. Very few birds at either these or at the masses of *Leonotis* on the Chipete outskirts. Two bulbuls (*Pycnonotus layardi*) at *Kniphofia* and one sunbird at *Leonotis* was the sum total.

"I saw one head that was bent over in such a way as not only to give a bird a very difficult approach (relatively to the flowers' natural openings), but in which those flowers that opened on to this unusual approach were splayed away from one another, scanty, irregular, and not mutually protective. I had already examined many heads without finding greater damage than I have already noted in the case of those at the dam, and I was curious, therefore, to know how so irregular a head had fared—so made my way to it. I found several of the irregular flowers (none of the regular ones) with discontinuous slits or punctures. Another head, standing right beside this one and normal except for a 'twist' devoid of flowers that was still, however, in the region of unopened buds, showed no damage except a few of the normal slits. The two heads were not isolated, but stood together in the midst of a scattered clump of the plants. I therefore collected without selection all of the 20 heads that were nearest to them (even the furthest was within a very few yards), as well as these two, and took them home and examined them with the following result:—

"No. 1 (Pl. 32. fig. 5). The abnormal raceme in question. It was bent over at right angles just below the 'mat,' probably as the result of insect (Acridian ?) damage at that point. Still, some of its neighbours, damaged exactly similarly and quite as deeply and severely, remained erect. The open flowers on the upper surface were as I have described them. Their openings were largely averted from an approaching bird and their bases exposed. All the remaining flowers were densely and normally packed.

"Of the 35 flowers that were more or less exposed (by irregularity and lack of mutual protection) to a bird perched on the top of the horizontal portion of the mat, 29 showed punctures and bill-marks, *in every case on the side exposed*. This was most strikingly the case. Thus the flowers leaning

to the left had their right sides punctured, those to the right their left sides, those leaning pointwards their near side. One flower had as many as five punctures, some others three or two. Drops of nectar were oozing from the more basal punctures, and the damage was in all cases such as would obviate contact with the anthers and stigma. In addition to these punctures and bill-marks were a few long *slits* of the type already described, continuous with the margin of the perianth. These were not entirely confined to the exposed surfaces *. The six undamaged exposed flowers were those nearest the tip, and had possibly only opened since the bird's visit.

"Of the remaining 114 flowers that were normally placed and mutually protective only six were damaged, and these with only the usual slits I have just referred to.

"No. 2. (No. 1's immediate companion): 5 slits, 4 small bill-point marks scattered at random and on non-exposed surfaces, probably accidental. Flowers everywhere densely mutually protective.

"No. 3. A very perfect specimen with a very large number of flowers (approximately 306 out at the moment), densely packed. There were 48 of the usual slits, most of them very slight and all of them most certainly accidental, as none could have assisted in the procuring of the honey or the evading of the pollen.

"No. 4. A small head with few flowers (about 100 out) had a bare tract half an inch wide extending spirally from the tip of the raceme to nearly the base of the flowers actually out. The flowers immediately below it had their bases exposed. The highest (latest out), to the number of 10 or 11, showed no marks on their exposed side and only one of the usual underside slits. Of the 6 flowers exposed lower down the spiral, 4 were slit on the side exposed, none elsewhere. Of the remaining approximately 84 flowers, mutually protective but less utterly densely packed than in No. 3, 7 had the usual slight slits.

"No. 5. A still smaller head. The latest flowers to *commence* to open were already those at the tip of the raceme, and a bird perching there might well have been expected to slit their upper surface as is done in *Leonotis*. There was no such damage, but the flowers were in any case barely ready. Slightly lower, however, there was a fault—a number of flowers, a closely-packed bunch of them, pointing *upwards* at as strong an angle as they *should* have taken *downwards*. The flowers immediately below them pointed in the normal direction. The result, of course, was that both lots were exposed, 8 as to their lower surface, 5 as to their upper. Four of the latter were punctured (3) and slit (1) on their upper exposed surfaces only (none elsewhere),

* An observation yet to be described subsequently threw light on the causation of these slits. It showed that they were purely accidental and need not be found more on exposed surfaces than on others.

and 4 of the 8 were slit or punctured as to their lower (exposed) surfaces—none elsewhere. The basal holes were all oozing. Of the remaining flowers of the raceme 16 showed the usual 'accidental' slits.

"No. 6. A very perfect head, but with only a few rows at the base in flower as yet and the 'mat' barely commencing to form. 4 'accidentals' out of about 100 flowers.

"No. 7. 6 slits and 2 bill-point marks. A good head with a little more mat than No. 6; about the same number of flowers open.

"No. 8. A very small head, about 50 flowers open: 2 'accidentals.' Two faults were present, but the opening flowers had in each case barely reached them, and no damage had been inflicted on the bases of the exposed buds.

"No. 9. Small head, nearly over, about same number of flowers as last. 3 'accidentals' and 3 punctures of a type that seemed unlikely to have been accidental. The three flowers in which the latter were present occupied the same position in their respective rows—that is, one was immediately below the other—and all three showed the same puncture, on the right side. The uppermost was lying over to the other side, leaving the right side exposed. The flower immediately below it, though also lying over, was intact. The two below this again were punctured, though, owing to their by now pressed-down condition, it was difficult to say what may have been their actual position previously.

"No. 10. A smaller raceme with about 100 normal flowers. One slit and three bill-point marks noticed.

"No. 11. A very fine raceme, but with fewer flowers out than in No. 3. The flowers were distinctly wider at the mouth than in No. 3, with segments more splayed; each mouth was separately conspicuous to a greater extent than in No. 3. All this may have accounted for my finding only 5 'accidentals' out of about 150 flowers actually open.

"No. 12. A small raceme with about 110 flowers in all open. Flowers small-mouthed and close-packed as in No. 3. Over 20 'accidentals.'

"No. 13. About 70 flowers; no faults, 5 'accidental' slits.

"No. 14. Another small head. One fault involving about 10 flowers, some of which, however, were only just out. Four of the 10 were slit and punctured on the side towards the fault, another was merely slit on the side away from it. Of the remaining flowers over 25 were slit, *i.e.* about a third of the whole.

"No. 15. About 60 flowers; no appreciable faults, 10 'accidentals.'

"No. 16. Small raceme, no mat yet, about 50 flowers, and 5 probable 'accidentals.' A serious fault, but the 8 flowers affected were only just open or beginning to open and remained still quite unpunished.

"No. 17. About 120 flowers; no faults, 10 'accidentals.'

"No. 18. A very good raceme, about 150 flowers separately conspicuous as

in No. 11, but, at any rate on one side, close-packed as in No. 3. 16 'accidentals.'

"No. 19. A very good raceme, but barely beginning to make a mat. Barely 100 flowers, dense and not very conspicuous individually—much like No. 3. 24 'accidentals.'

"No. 20. A large lax raceme, with flowers rather large-mouthed as in No. 11 but by no means tightly packed. Still, only one definite fault, and that barely coming within the region of the present flowers. About 150 flowers out, and only 5 'accidentals.'

"No. 21. Of exactly the same type as the last. 69 flowers out, no fault, only one 'accidental.'

"No. 22. About 130 flowers, same type as last, no faults; 2 'accidental' slits and 2 or 3 bill-point marks.

"The total number of flowers given is in each case only approximate, as I found it difficult to draw an exact line between flowers still in use and those that were already, by being bruised and torn by the bird's feet, becoming consigned to the 'mat.'

"I again watched hive-bees at the pollen and honey and a smaller bee at pollen: also pollen-eating flies. Ants of at least three species were also present.

"Visited yesterday's two *Kniphofia* on the outskirts. That damaged yesterday had been weighed down half-way to the ground by something but showed no other damage. The other (undamaged yesterday) was to-day damaged as the first had been yesterday. Fewer flowers were implicated (about 7 in one place and 1 in another) and the work was neater. On yesterday's I found a very good piece of evidence (previously overlooked) to indicate that it had been the work of a bird. Three flowers had been seized together, two of them showed the clear impress of the upper mandible and one of the lower, as shown in Pl. **32**. fig. 3.

"On leaving I removed some of the flowers from the upper surface of the leaning head in order to see whether the flowers thus exposed would be pierced."

"June 6th. Examined the day before yesterday, above the dam, seven or eight heads of *Kniphofia* in which the flowers had reached the apex and could therefore be attacked from above, even if awkwardly, by sunbirds perching there. About half showed no damage at all other than the usual slits; the remaining heads did show, in a small proportion of only their uppermost flowers, definite punctures and slits on their upper surfaces. These might have been made by a bird perching either above or below, and in either case would probably have enabled him to avoid contact with the anthers. In one case, a raceme with about 50 flowers open, the apex was bent over in such a way as to afford quite a convenient perch to a bird, and a large proportion of the flowers growing near the apex were slit

(discontinuously) or punctured, in some cases right at the base, and exuding honey, always on the upper surface. In this case the damage could hardly have been inflicted from below, as the flowers near the point tended, as often happens, to take an upward angle. The lower flowers, protected from above by others, showed only five of the usual 'accidental' slits, most, if not all, on the under surfaces and not corresponding at all to the damage to the uppermost flowers. I could have given interesting detail at the time had I had leisure to write it up. The raceme is now in front of me, but the flowers are already so shrivelled that they are difficult to re-examine.

"Before leaving them (on the 4th) I bared the stems of nine racemes just above the highest flowers out, to a sufficient distance to give a sunbird a convenient perch *above* the flowers—a perch such as *Leonotis* offers. I saw no sunbirds at either the *Kniphofia* or *Leonotis* plants at the dam on the 4th or again to-day (6th)—merely a pair of bulbuls (*Pycnonotus layardi*) on each occasion; and I was struck by the fact that very few indeed of the *Leonotis* flowers there showed the slits that characterize nearly every flower on the outskirts. Evidently the dam is not frequented by any very destructive individuals—a pity from the point of view of my observations on *Kniphofia*. The nine peduncles partly stripped were in three separate clumps, three in each, the remaining flower-heads in each clump being left intact as a control.

"This morning early I stripped three heads in another clump near which two sunbirds were visiting *Leonotis*, and went on to visit the two *Kniphofia* plants on the lower outskirts, to which I have previously referred. Both racemes had been broken off and were gone. I presumed Kaffirs had done it, but 23 yards away, in a track showing baboon-spoor (*Papio cynocephalus*, Geoff.), I found where one of the heads had been stripped of its flowers and, beside these, a baboon-dropping containing fruits of *Physalis peruviana*, Linn., and of other species. The flowers were already too shrivelled to enable me to judge whether they had been sucked.

"At noon I definitely examined all the stripped *Kniphofia* heads of the 4th. In one clump no raceme showed damage, and it did not strike me in time to look at the thin papery bracts left by the removal of the flowers for evidence of a bird having perched there. In the next clump these bracts in all three racemes were in parts flattened down or otherwise distorted, indicating that the stem had been grasped. In one raceme I had made my opening rather high and the open flowers had not yet reached it. Yet even here a bud not yet quite opening had had its exposed upper surface severely slit. The other two racemes showed upper side damage, and, after examining carefully all their unstripped neighbours and finding that these showed *no* corresponding damage—merely what I have termed 'accidental' damage,—I picked them and later examined them at leisure, as I also did the three stripped racemes of the third clump, having first

examined *their* neighbours too, with the same result as in the other case. These three racemes, I ought to add, showed no disturbance of the bracts.

"In the first of the two second-clump racemes (examined row by row, each individual flower being removed for separate examination) the first row consisted of 16 just open flowers and 4 buds. There were 23 flowers in the second row. In the yet lower rows a large proportion of the flowers were already becoming bruised and flattened down, and some of the slits may possibly, therefore, have been the work of claws.

	Intact.	Slit above.	Slit below.	Basal punctures.
1st row	10	3	2	5
2nd row	14	6	3	—
Lower rows	9	22	25	—

The basal punctures were confined to the exposed surface of the exposed row and honey was exuding from them.

"The second raceme had wider-mouthed flowers than the first. Its injuries were as follows:—

	Intact.	Slit above.	Slit below.	Basal punctures.
1st row	10	6	3	2
Lower rows	73	7	36	—

"Of the three third-clump racemes, two, of much the same type as the second raceme above, showed slits (3 and 1 respectively) in the upper surface of flowers of the top row, and their injuries generally were about on a par with those of that raceme. I did not make an actual count here, but ran carefully through all the flowers to gain a correct general impression. In addition, one raceme had four non-continuous injuries in its top row, three of them at the bases of flowers. They were capable of infliction by a bird perched below, owing to the scantiness of the intervening flowers. None of the lower ones showed any such injuries.

"The third raceme's flowers possessed the same constricted neck as those of the first raceme described. In this case there were no basal injuries, but a number of upper surface slits not penetrating far, both in the topmost row and those below it, as well as the usual slits elsewhere. So far as I could tell without actually counting, its injuries of all rows were very much the same in quantity and character as the lower-row injuries of the other constricted raceme, and I now see the probable reason. The neck is in a large proportion of cases so narrow that a bulbul's bill could not be inserted without splitting the flower. Damage of this kind would probably not prejudice the flower's chances of pollination, but the basal slits and punctures distinctly would."

"*Later*: *evening*.—I ran over to Chipete at sunset and partly stripped 31 more flowers—10 in one place and 21 in another—as well as 9, of which

I stripped only one side. I expect no results, however, as I examined a large number of *Leonotis* heads in various spots thereabouts and could only find two individual flowers that had even the corolla split. Also I examined eight *Kniphofia* plants the flowers of which had reached the apex and so had their bases exposed, and racemes with faults resulting in the same thing, and only found one flower in all that had been punctured. Evidently there are few or no birds of destructive tendency haunting that slope at present. For that matter sunbirds appear to be visiting the flowers there very little in any case : I saw nothing at the numerous *Leonotis* plants and only one bird at a *Kniphofia*. This was a shrike, *Chlorophoneus olivaceus* (Shaw) Cab. He was perched on the 'mat' of a raceme and was thence probing quite slowly and carefully one after the other the flowers above him. It seemed utterly unlikely that his bill could enter the average flower without splitting it, and it struck me as a good opportunity to test this view as to the cause of the split perianths. On the shrike's leaving, I took the flower : also, for comparison, a neighbour 8 yards away and one 80 yards away. It was possible that the former and probable that the latter had not been visited by him. I noticed at once that many of the flowers in the shrike's raceme were split, and absolutely freshly split, the edges glistening and wet ; but the shrike had used no force and had done no tearing. I felt sure of this, having been close to the bird and having used my glasses as well. There were no wet edges in the 8-yard raceme."

I have now examined all three heads with the following result :—

	Unsplit.	Split above.	Split at side.	Split below.	More than half way.	Less than half way.	Half way.
1. Shrike's raceme..	31	24	22	6	22	10	18
2. 8-yard " ..	78	4	9	10	1	18	4
3. 80-yard " ..	46	0	0	0	0	0	0

No. 1 has the largest flowers, No. 2 the next largest, No. 3 the smallest through a somewhat severely constricted neck which the others lack.

In No. 1 at least 31 slits, from their fresh condition, seem to have been the work of the shrike. The remaining 18 are more doubtful, but even here some seem thoroughly fresh in part, as though the shrike in pushing well in had extended a previous slit. Comparing the fresh with the doubtful I found :

	More than half way.	About half way.	Less.
Probably shrike's flowers	17	11	4*
Possibly not his	5	8	6

* There is a discrepancy between the total number of slit flowers given in these three tables. In the first the total is 52, in the second 50, and in this 51. I can only suppose that I did not compare the totals at the time of counting, and that once one, once two flowers were omitted, probably amongst older flowers that were beginning to join the "mat."

A point that interested me in No. 2 was that the damage was confined to the lower rows out. This and the dry edges of the slits suggested that it had not been visited for a day or two. I counted the flowers of the upper and the lower rows separately. Result :—

	Split.	Unsplit.	
Upper rows	0	41	And 4 on the border line, hard to assign to either category, were also split.
Lower rows	19	37	

It seems probable that the diameters of the bill and of the flower relatively to one another determine whether and how deeply a flower will be split, and shape of bill and relative strength of different parts of the perianth whether the slits will be at side, above, or below.

Summary :—

1. Numerous slits were found in the flowers of *Kniphofia rhodesiana*. They were probably for the most part produced accidentally, by the insertion of a bill too large for the flower. There was much variation in the diameter of the flowers on different racemes, and it was the small flowers or those with constricted necks that, on the whole, showed most accidental slitting. At the same time it was not a form of injury that seemed likely to lessen the flower's chances of pollination.

2. Punctures, mostly basal and evidently the intentional work of birds, were also found. They were only found in exposed flowers and only on the exposed surfaces of these—in eleven different racemes in all. Many hundreds of unexposed flowers were also examined, and none showed these punctures.

3. It was perhaps interesting (from the selectionist point of view) that the character determining the incidence of the *harmless* form of damage was a very variable one—narrow flowers were as abundant as wider-mouthed ones; while the exposed flower-bases that invited the more prejudicial form of damage were extremely uncommon.

I. Observations on other Plants.

Halleria lucida, Linn., a small tree occurring on the outskirts of the Chirinda Forest and elsewhere, has rather short, tubular, brown corollas that are very much frequented by the rather short-billed sunbird, *Anthothreptes hypodilus*, Gadow, as well as by *Cinnyris olivacina*, Gadow. The pedicels are tough but exceedingly thin and pliable, and their very instability would probably make attempts to pierce the corolla in most cases a failure. I have examined a very large number of the flowers and seen no evidence of piercing, the frequently split base of the corolla-tube having been in every case obviously due to the swelling of the fruit within.

In 'The Ibis' (1908, pp. 31–45) I mentioned a number of the flowers that are frequented by our various local sunbirds. The list might be very greatly extended, for these birds haunt not only the flowers that depend on them to some extent for pollination, but visit an immense number of mainly entomophilous species as well, and, but for my failure regularly to note down such flowers as I have from time to time seen them visiting, my own list alone would be a very lengthy one.

In *Gouania longispicata*, Engler, and *Aberia macrocalyx*, Oliver, both frequented by sunbirds—the latter in particular by *C. olivacina*,—the honey-discs are open to all comers, and no "breaking" is necessary. The same roughly applies to the Cearà rubber-tree. However, "during March" (1907), "when my rubber-trees (*Manihot Glaziovii*, Müll.-Arg.) were in full bloom, several of these birds" (*Cinnyris chalybæus*) "frequented the plantation daily, and on the 22nd of that month Odendaal shot a male there, the stomach of which I found to be distended by a ball of elastic brown rubber" ('Ibis,' 1908, p. 38). I judge that the bird, in attempting to extract the honey, had perhaps found it difficult to avoid pricking the discs, and that it could not have survived much longer. However, the stomachs of two others shot in the same trees had only insect-remains for their solid contents.

In the hanging flowers of *Calpurnia lasiogyne*, E. Meyer, roughly reminiscent of laburnum and visited by *Cinnyris niassæ*, the thin pliable pedicels probably play the same part as in *Aloë Swynnertonii* and *Halleria lucida*, and I have found no traces of damage from outside to the bases of the flowers excepting on the part of insects. Some very fine punctures and scratches on the petals have probably been from within, and are likely simply to represent "bad shots" on the part of the sunbirds. These hang head downward from the vertically suspended peduncles, and turning their bills upwards probe the flowers from below.

Melia Azedarach, Linn., an importation from the East, is frequented at Chirinda by sunbirds when in bloom, particularly, so far as I have observed, by *C. chalybæus* and *C. niassæ*. I have also seen *C. kirki* visiting its flowers. A male *C. niassæ* that I shot after it had been visiting the flowers, for a considerable time had its lower throat and breast dusted with pollen, and as it had seemed frequently to brush the flowers with these parts in attempting to reach others further away, and may thus have possibly come into contact with the anthers fringing the staminal tubes, it is possible that the pollen may have been that of the *Melia*.

These *Melia* flowers seem, however, in any case to be essentially entomophilous in character; and it is interesting to contrast their intense scent with the practical lack of it in *Erythrina tomentosa* and *Grevillea robusta*.

The remaining species seen visited at Chirinda by birds will be given below, as well as a fuller list of the birds themselves.

J. The Attraction.

Are the birds for the most part attracted directly by the nectar itself, or, indirectly, by the insects attracted by the latter?

Mr. Scott Elliot records (Ann. Bot. iv. 265–278) that he saw a pair of *Cinnyris chalybæus* carefully searching the heads of *Leucospermum conocarpum*, R. Br., for insects as much as for the honey; but so far as my own observations are concerned, I should say that the honey was in nearly every case the main and sufficient attraction, though insects were taken incidentally too. In *Erythrina Humeana* I have in several cases carefully examined such flowers as I could reach, in each case bending the twig down cautiously into my net to prevent escapes, and I have been surprised at the relatively small proportion of even much-sprung flowers that contained a single insect of any kind. Some, too, of the very few small insects I did find were almost certainly of highly unpleasant species. The time of year was unfavourable to them, but the main fact seemed clear—that it could hardly have been for insects that the birds were visiting the flowers so assiduously and in such numbers. In fact, *Colius striatus* var. *minor*, Cab., a most assiduous and abundant attendant of *E. Humeana*, has been shown both by general observation and, for this particular locality, by my examination of from sixty to seventy of its stomachs, probably not to be an insect-eater at all. To elucidate the same point in *Grevillea* I once spent half an hour in the branches of one of my *G.-robusta* trees. Some of the birds fed within five feet of me, *on the honey*, and I came to the conclusion finally that, though they were glad enough to take available insects of acceptable species (I witnessed four or five attacks, as against a large number of definite refusals), the nectar was what actually brought them to the flowers. Very few flowers indeed had insects, yet a bird arriving at a raceme would dip into practically *every* flower, taking them rapidly and systematically one after the other, the tip of its bill glistening the while with the honey. I saw only bulbuls and sunbirds on this occasion; but these later remarks apply equally to the orioles and weavers that I have watched at these flowers at other times through my glasses. When placing racemes of *Erythrina tomentosa* or *Grevillea robusta* in my bulbul's cage, I have first examined them to make sure that no insects were included. In spite of their absence the bird has always tackled the flowers with eagerness, and, going through them systematically after the manner of a wild bird, has quickly emptied them of such honey (often literally overflowing) as they contained. In these and other ornithophilous species the honey has been exceedingly abundant, even in such a year of drought as 1912. A shake to a branch sometimes brings a shower of drops tumbling out of the flowers, and in *Grevillea robusta* the leaves and twigs are often sticky with the honey that has overflowed from the flowers above them. It seems to be

quickly replaced when drained. I have occasionally seen ants drowned in the honey of *G. Banksii*—once as many as eight in a single brimful flower ; and this would doubtless be an additional attraction to such birds as like them.

I think I can safely say that hive-bees, which attend even these flowers (and especially those of *Grevillea robusta*) sometimes in considerable numbers, and appear to assist in their pollination, probably do not help to attract the birds. Not only have I witnessed no attack on them there, apart from a rejection by *Cinnyris chalybæus*, but I have in the course of my various experiments offered hive-bees to several species of birds. These, with only two or three exceptions, have rejected them with more or less marked dislike under circumstances that precluded the supposition that the sting might be the cause of rejection. The experiments showed, in fact, that hive-bees—and various other Aculeates—are definitely "distasteful" to many species of birds, their stings being often probably quite a secondary defence against a large proportion of these animals.

K. The Deterrent.

What causes the bird to avoid the natural opening? In the case of *Gardenia tigrina* a glance at the diagram (Pl. **32**. fig. 1) is sufficient to show that there the difficulties offered by the natural opening, even to a bird of the size of *Cinnyris chalybæus*, are probably an ample deterrent ; and my earlier observations generally led me to the conclusion that the bird simply took the easiest way to the nectar. If the natural opening were somewhat more difficult than piercing or than utilizing a previous puncture, it would be avoided ; if easier, it would be taken. Roughly speaking, this is perfectly true of the less destructive birds. Those birds, however, that enter every, or nearly every, flower wrongly must have some further reason for their action, for, as already described, I have sometimes seen them go to real trouble, apparently, to avoid the mouth of the flower. There must be something there that is objected to. What is it?

I quote the following from one of my *Erythrina* notes :—I was watching a flock of widow-birds (*Coliopasser ardens*, Bodd.) at work on the flowers of *Erythrina tomentosa*. "A bird that had entered a flower in a normal manner hastily withdrew its head and shook it vigorously and repeatedly. Something inside the flower—possibly a nauseous or a stinging insect, or, far more likely, merely honey or pollen in the nostril—seemed to have annoyed it very greatly, but it soon went on to other racemes."

This suggests that pollen or over-abundant honey—or the stamens and pistil themselves—getting into the nostrils or eyes might deter birds from using the natural opening. On the other hand, I have watched large numbers of birds entering flowers by their natural openings, and the occasion

described is the only one in which I have seen discomfort of this kind shown; also, only certain individual birds trouble always to avoid the proper opening. I am myself inclined to believe that the pollen itself on the *plumage*, and especially round the bill, where it would be harder to clean off, might be in itself a sufficient deterrent. Birds, and especially some individuals, mostly male, being very great dandies, are intolerant of foreign matter on their plumage, and will go to immense trouble in preening the latter. And pollen is, as I have seen, deposited in considerable, and I should have thought objectionable, quantities on and in the feathers of such birds as do not avoid the natural openings.

This is, however, merely a theory to account for the actual fact that some birds do go to some pains to avoid the natural opening of the flower.

L. Lists of Birds and Flowers observed.

(*a*) Birds seen visiting flowers on or near Mount Chirinda:—

Oriolidæ.

1. *Oriolus larvatus*, Licht. Black-headed Oriole.

Ploceidæ.

1. *Hyphantornis jamesoni*, Sharpe. Jameson's Weaver-bird.
2. *Sitagra ocularia*, Sharpe. Smith's Weaver-bird.
3. *Sycobrotus stictifrons*, Fischer & Reichw. Spot-headed Weaver-bird.
4. *Estrilda astrilda* (Linn.) Swains. Common Waxbill.
5. *Estrilda incana*, Sundev. South-African Grey Waxbill.
6. *Neisna kilimensis*, Sharpe. Kilimanjaro Waxbill.
7. *Coliopasser ardens*, Bodd. Red-collared Widow-bird.

Promeropidæ.

1. *Promerops gurneyi*, Verreaux. Natal Long-tailed Honey-bird.

Nectariniidæ.

1. *Nectarinia famosa*, Shelley. Southern Malachite Sunbird.
2. *Nectarinia arturi*, P. L. Scl. Sclater's Beautiful Sunbird.
3. *Cinnyris microrhynchus*, Shelley. Least Bifasciated Sunbird.
4. *Cinnyris leucogaster*, Vieill. Southern White-breasted Sunbird.
5. *Cinnyris venustus* var. *niassæ*, Reichw. Nyassa Sunbird.
6. *Cinnyris chalybæus*, Shelley. Cape Lesser Double-collared Sunbird.
7. *Cinnyris afer*, Shelley. Greater Double-collared Sunbird.
8. *Chalcomitra gutturalis*, Cab. Southern Scarlet-chested Sunbird.
9. *Chalcomitra kirki*, Shelley. Kirk's Amethyst Sunbird.
10. *Cyanomitra olivacina*, Gadow. Lesser Olive Sunbird.
11. *Anthothreptes collaris* var. *hypodilus*, Gadow. Zambesi Collared Sunbird.

Zosteropidæ.

1. *Zosterops anderssoni*, Shelley. Andersson's White-eye.

LANIIDÆ.

1. *Chlorophoneus olivaceus*, Cab. Olive Bush-Shrike.

PYCNONOTIDÆ.

1. *Pycnonotus layardi*, Gurney. Black-capped Bulbul.
2. *Phyllostrophus milanjensis*, Shelley. Milanji Bulbul.

SYLVIIDÆ.

1. *Sylvia simplex*, Lath. Garden Warbler.
2. *Phylloscopus trochilus*, Boie. Willow-Wren.
3. *Prinia mystacea*, Rüpp. Tawny-flanked Wren-Warbler.

COLIIDÆ.

1. *Colius striatus* var. *minor*, Cab. Natal Speckled Mouse-bird.

That is, 28 species of birds belonging to one Picarian and eight Passerine families.

(β) The flowers of 7 species of plants, of 5 orders, were visited by birds other than sunbirds. They were

Erythrina Humeana, Spreng.; *Erythrina tomentosa*, R. Br.; *Grevillea robusta*, A. Cunn.; *Grevillea Banksii*, R. Br.; *Kniphofia rhodesiana*, Rendle; *Eucalyptus ficifolia*, F. Muell.; and *Leonotis mollissima*, Gürke.

All the flowers were also visited by insects, and these probably take some part in their pollination, but, with the exception of the *Eucalyptus* (visited by *Pycnonotus layardi* but pollinated chiefly, I think, at Chirinda by hive-bees and Sphingidæ), they were probably mainly ornithophilous.

(γ) Sunbirds, on the other hand, visited not less than 40 species of 19 orders, and I could add still further to the list were my memory better. A large proportion were mainly entomophilous species.

BIXINEÆ. *Aberia macrocalyx*, Oliver.

MALVACEÆ. *Hibiscus* spp.

MELIACEÆ. *Melia Azedarach*, Linn.

RHAMNACEÆ. *Helinus mystacinus*, E. Meyer, and *Gouania longispicata*, Engler.

LEGUMINOSÆ. *Phaseolus vulgaris*, Linn. (on Mr. A. S. Gifford's authority), *Erythrina Humeana*, Spreng., *Erythrina tomentosa*, R. Br., and *Calpurnia lasiogyne*, E. Meyer.

ROSACEÆ. Peach (*Prunus Persica*, Stokes).

MYRTACEÆ. *Eucalyptus ficifolia*, F. Muell., and other Eucalypts, but I cannot remember details of the latter; *Callistemon lanceolatus*, DC.

RUBIACEÆ. *Gardenia tigrina*, Welw., and *Fadogia Cienkowskii*, Schweinf.

SCROPHULARIACEÆ. *Halleria lucida*, Linn.

BIGNONIACEÆ. *Podranea Brycei*, Sprague, *Markhamia lanata*, K. Schum., *Catalpa bignonioides*, Walt., and *Kigelia pinnata*, DC.

ACANTHACEÆ. *Pseudocalyx africanus*, S. Moore, and *Macrorungia pubinervis*, C. B. Clarke.

LABIATÆ. *Salvia splendens*, Ker-Gawl., *Achyrospermum Carvalhi*, Gürke, and *Leonotis mollissima*, Gürke.

PROTEACEÆ. *Protea madiensis*, Oliver, *P. uhehensis*, Engler, *Faurea speciosa*, Welw., *Faurea racemosa*, Farmar, *Grevillea robusta*, A. Cunn., and *Grevillea Banksii*, R. Br.

LORANTHACEÆ. *Loranthus Swynnertonii*, Sprague, and others.

EUPHORBIACEÆ. *Manihot Glaziovii*, Müll.-Arg.

CANNACEÆ. *Canna indica*, Linn., subsp. *orientalis*, Rosc., and quite three other species.

IRIDACEÆ. *Gladiolus* spp.

MUSACEÆ. Banana (*Musa sapientum*, Linn.).

LILIACEÆ. *Dracæna fragrans*, Ker-Gawl., *Kniphofia rhodesiana*, Rendle, and *Aloë Swynnertonii*, Rendle.

The ready adoption by our local birds of the newly imported species mentioned (*Melia Azedarach*, *Phaseolus vulgaris*, *Prunus Persica*, *Eucalyptus ficifolia*, *Callistemon lanceolatus*, *Catalpa bignonioides*, *Salvia splendens*, *Grevillea robusta*, *G. Banksii*, and *Manihot Glaziovii*, not to mention *Canna indica* and *Musa sapientum*) would seem to show that nectar-eating birds must experiment freely on any new flowers that they may come across.

M. SUMMARY OF MAIN POINTS.

1. Not only mainly ornithophilous flowers, but a number of essentially entomophilous flowers were visited by sunbirds.

2. Not only sunbirds (which indeed are often great evaders of the natural opening) but many other birds as well visited certain flowers freely for their honey and were probably of use to them for cross-fertilization.

3. Certain birds, and some individuals more than others, apparently disliked something in connection with the natural opening—possibly the being besprinkled with pollen—and tended always to enter flowers by breaches made by themselves or their predecessors.

4. The plant's liability to such breaching depended primarily on whether it came within the "beat," for the time being, of a destructive individual or flock.

5. Other birds tended, contrariwise, to enter the flowers by their natural

openings and so to be of use to them for cross-fertilization, *excepting* in the case of individual flowers that happened, through inconvenience in their own or the bird's position, &c., to offer some difficulty. If these were insufficiently protected as well, they were often either pierced or the openings already made in them by the more indiscriminating birds were utilized.

6. Protection took several forms—thin, pliable pedicels, massing of the flowers for mutual protection (a possible factor in the evolution of the capitulum), thickening of parts, and so on.

7. Insects as well as birds tended to utilize the breaches made by the latter, and so probably in large part failed to counteract the birds' discriminative influence.

8. In most cases the eliminative effect, if any, of the damage was not traced. In two instances it was (for individuals) immediate and clear, flowers of a certain type being bodily removed.

The observations were suggestive, but over-scanty, and the effect, if any, of the damage was insufficiently followed out *. They were fairly consistent, however, so far as they went; and the fact that damage was confined to particular areas, often adjoining other areas in which it was absent or of another kind, and that such areas were not necessarily the same at different periods, is, I think, useful for its warning that where purely negative evidence is found, it should not be regarded as necessarily conclusive in matters of this kind.

ADDENDUM.—*March 24th*, 1914.

Since the above paper was read, Mr. Charles Oldham has most kindly called my attention to a paper published in 'The Zoologist' for January 1896, pp. 1–10. It is by Dr. John Lowe, and is entitled "Notes on a newly discovered habit in the Blackcap Warbler and other birds."

His observations were carried out in Tenerife, in the Grand Canary,

* I have, amongst other shortcomings, not yet attempted the very necessary experiment of excluding the birds from the various flowers they most commonly visit. Mr. M. S. Evans published in 'Nature' (1895, Jan. 3rd, p. 235) an interesting account of such an experiment. He protected from eighty to a hundred healthy flowers of *Loranthus Kraussianus*, Meissn., from their Sunbird visitors (*Cyanomitra olivaceus*, Shelley)—but one would judge from the account that he probably excluded insects too,—and he "found that when thus protected ... none exploded, and, as a consequence, not a single flower within the bag set seed. They seem to be quite sterile without outside help: the anthers dehisce, but at a level below the capitate stigma, and as the corolla-tube is generally upright the pollen is lost even as a self-fertilizing agent." He came to the conclusion that the plant depended on the *Sunbirds*; for bees, though they followed the birds, seldom themselves caused an explosion. He came to a similar conclusion with regard to *Loranthus Dregei*, Eckl. & Zeyh., in which species the Sunbird-caused explosions were so violent as to send not merely the pollen but the whole anther all "flying into space."

Algiers and Corsica, and are exceedingly interesting. Blackcaps (*Sylvia atricapilla*) were watched biting small pieces out of each of the two nectar-concealing calyx-segments of *Hibiscus Rosa-sinensis*, Linn., revisiting them at intervals, and later in the day, when the moisture had dried, extending the tears ; they were also seen in the early morning pecking at the ripe pulp and tearing pieces off the skin of Yucca berries, and later revisiting them; Blackcaps and *Phylloscopus fortunatus*, Tristr. [= *Collybita canariensis*, Mr. Bannerman tells me] were watched visiting the similarly punctured perianths of *Aloë vera*, Linn. ; a Garden Warbler (*Sylvia simplex*, Lath.) "was seen to pick out a small piece at the base of each corolla-tube" of *Antholyza æthiopica* * "in turn as it ascended the stem" ; and Black-headed Titmice (*Parus tenerifæ*, Tristram) made openings in any or all of the calyx-segments of an *Abutilon* in which the calyx "had nectar all round the receptacle." Here Dr. Lowe adds :—"The object of this proceeding seems to be to afford a ready means by which the ants may arrive at the nectary. These, after the calyx is torn (never before . . . .) enter in great numbers, and after consuming the nectar are found in a semi-torpid state. . . . They then fall an easy prey to the Tits, which visit the flowers at short intervals during the day, and clear off the ants."

The motive for piercing—whether honey or insects—is the main point discussed; and Dr. Lowe seems to lean towards the view that insects are the main, if not the sole, object the bird has in view. Thus of the Blackcaps he says :—"The object with which these preparations are made is, as it would seem, not merely for the purpose of sucking the nectar but in order to furnish a bait to attract insects to serve as prey." And again :—"It is of course possible that the Blackcap may, in the first instance, feed on the nectar, but certainly neither it nor *Phylloscopus*, at their subsequent visits, does anything more than search for insects. . . . Whether this is the primary object is not so clear. It may be that the Blackcap is a nectar-eating bird, though there are no observations to show this †. I certainly think it very probable that the Garden Warbler punctures *G. Antholyza* for the purpose of obtaining the nectar, in the first instance ; but in the case of *Abutilon*

* Whether *Gladiolus æthiopicus*, Draper, *Antholyza æthiopica*, Linn., or *Gladiolus Antholyza* [=*Antholyza nervosa*, Thunb.], is not made completely clear in the text; but the figure given certainly corresponds best with the second of these. On looking through the material of these plants in the British Museum Herbarium, I was interested to find one flower of *A. æthiopica*, Linn., and at least three of *A. nervosa*, Thunb., with basal punctures that had quite likely been inflicted by birds. The specimens in which these punctured flowers occurred had in each case been collected in the Cape Peninsula.

† The pollen-covered foreheads of Capt. Boyd Alexander's Blackcaps, which I refer to more fully below, are, it seems to me, possibly suggestive in this connection, though it might doubtless be argued that they were merely following insects into the flowers.—*C. F. M. S.*

I cannot believe that *Parus* would search for nectar ; and very clearly I think the laceration [later in the day] of the calyx was made with the object of enabling ants to reach the nectary. *Phylloscopus* may possibly be a nectar-eater, but this is doubtful."

Dr. Lowe goes on to discuss whether the habit is acquired or instinctive, and is led to the former conclusion by the fact that he has only observed imported flowers thus treated. At Chirinda both imported *and* indigenous flowers are thus treated, and the imported flowers are sometimes not very different in principle to indigenous ones ; but it does seem to me a habit that, acquired originally perhaps as a lucky or a clever invention, is likely in birds to have been spread and handed down by example. All our flower-haunting birds at Chirinda are of species that tend to go about in family parties for some little time after the young can fly, and the latter would certainly learn from their parents to pierce flowers or utilize previous punctures. Learning on indigenous flowers, they would apply their experience to imported species too, and find out by experiment or example the right spots to pierce.

To revert to the question of motive, Dr. Lowe's observations were most careful and exact, and I have myself, as already stated, seen insects attacked by birds that seemed to be visiting flowers primarily for the nectar. It is perhaps, however, worth noting that in his observations on the *Hibiscus* the Blackcaps made the usual perforations in spite of the fact that the ants—and a powerful attraction to them, aphides—were present already on the calyces, and that they (the ants) in any case ignored the holes in favour of the aphides ; a small wasp and a small bee were the only insects that visited them ; and that Garden Warblers (*Sylvia simplex*, Lath.) freely punctured *Antholyza* flowers in spite of there being practically no insects but hive-bees to attract. As for the question whether the warblers observed were nectar-eaters at all, I have myself watched *Sylvia simplex*, Lath., and *Phylloscopus trochilus* (Linn.) Boie, as well as that very common African warbler, *Prinia mystacea*, Rüpp., entering flower after flower and (*Sylvia* and *Prinia*) utilizing injuries, the main object, at any rate while I was watching, being in all cases quite definitely the nectar. I cannot help suspecting, therefore, that the habit of puncturing in such species will have arisen originally from a wish for the nectar, though it is, of course, certain that the birds would quickly learn that insects too can be obtained from the punctures, and might visit them, and even make them, for the sake of the insects as well as the nectar, or when disinclined for the nectar itself. Dr. Lowe's observation on the Black-headed Tits which kept revisiting the flowers they had pierced and clearing off the ants, is quite a striking one, and it may be that they perforate with a view only to insects, having learned the habit originally perhaps from what took place at punctures made by other birds. My own

experience of the intelligence and reasoning power of birds leads me to agree that this is exceedingly possible. Still, the Tits may themselves be nectar-eaters, as are, to a very marked extent, their cousins the White-eyes.

Should we, on the other hand, discuss not puncturing but the origin of the nectar-eating habit generally in birds, I think it will be admitted that it may well have arisen, in the first instance, as a result of following insects into flowers or picking them, drowned, out of the nectar, and so tasting the latter incidentally.

Dr. Lowe observes that *Phylloscopus* merely utilizes the damage inflicted by others, and quotes an exceedingly interesting observation by Mr. N. B. Moore in the Bahamas, from 'Nature,' April 25th, 1878, p. 509. The original note (which I have alone looked up, Proc. Boston Soc. N. H. xix. p. 245) may be summarized as follows :—A species of woodpecker (*Picus varius*, Linn.) was in the habit of extracting sap from a logwood sapling—" whose juice is very sweet, quite honey-like"—and other birds (*Certhiola flaveola* (Linn.), *Dendrœca tigrina* (Gmel.) Baird, and a species of *Anolis*, regularly, and *Dendrœca coronata* (Linn.) Gray, occasionally, also other individuals of *Picus varius*) were observed from Dec. 17th to Feb. 3rd to follow and utilize the woodpecker's "sap-pits." The *Certhiola*, moreover (as said to have been originally observed by Dr. Bryant), reaches the nectaries at the bases of the flowers of *Vereia crenata*, Andr. [= *Kalanchoë Afzeliana*, Britten] by means of short cuts through the corolla. Before being pierced, the flowers' nectaries were found never to contain insects ; but small black ants and very small winged insects soon found and entered the openings.

This utilization—certainly *intelligent* utilization in the case of birds—of the work of others is of course by no means uncommon in nature. To mention only one or two of various instances that happen to have come under my own observation : there are the *Charaxes* and other frugivorous insects that freely utilize the damage done to fruit by birds, Cetoniidæ, Trypetidæ, &c., and the birds that use other animals as " beaters." The large mixed bird-parties met with in tropical countries are a case in point ; and amongst simpler cases that have come under my own observation have been persistent attendance (for the insects put up) by a bulbul (*Pycnonotus layardi*, Gurney) on a flock of waxbills (*Estrilda astrilda* (Linn.) Sharpe) that were searching for seeds, by bee-eaters (*Merops apiaster*, Linn.) on a number of bulbuls (*P. layardi*) that were busy at fruit, and by drongos (*Dicrurus ludwigi* (Smith)), cuckoo-shrikes (*Graucalus cæsius* (Licht.)), and other birds on monkeys (*Cercopithecus albogularis* var. *beirensis*, Poc.) that were swinging idly along in the tree-tops.

It is interesting to find that Dr. Lowe's hive-bees, like mine, utilized openings made by birds to the exclusion of the natural openings as soon as the former became available ; and of still greater interest is what looks like

an instance of discriminative action by these. "Hive-bees were there" [at *Abutilon*] "in profusion, but they did not, as a rule, enter the flowers, as they could probe the nectary through the openings at the base of the petals. On one plant, however, where the flowers were large and well-formed, they did enter in the usual way."

Dr. Lowe also evidently found, as I have done, that not all individuals pierced. At any rate he believes that only the male Blackcaps did so. In the case of Sunbirds I seem to have found that the males are the chief but by no means the exclusive piercers. Mr. Ogilvie-Grant tells me in this connection that to the best of his recollection the Blackcaps, whatever their sex, that were brought home by Capt. Boyd Alexander from Cape Verde had their foreheads yellow with pollen. They may, of course, had to deal with some flower that did not lend itself to piercing. *C. F. M. S.*

EXPLANATION OF THE PLATES.

Plate 31.

Fig. 1. The two *Canna* heads of the observations of May 20, 1913. A. (*Canna* sp.), with flowers the natural openings of which were hard to reach; these were entered improperly even by the more accommodating Sunbird. The flowers of B. (*Canna indica*, Linn., var. *orientalis*), the natural openings of which were easily reached from the spathe, were, on the other hand, entered properly by her, though artificial openings were present and had been used by her more particular mate.

The arrows indicate the points of entry by the female, and the crosses the spots in which she punctured in the case of B. The flowers were picked and drawn immediately after the operation.

Fig. 2. A flower of *Leonotis mollissima*, Gürke, with only the corolla slit.

Fig. 3. (More usual): flowers of *L. mollissima* with both calyx and corolla slit, the calyx, as is natural, always further forward than the corolla.

Fig. 4. Rough drawing of Sunbirds at a verticillaster of *Leonotis mollissima*, to illustrate their methods. The verticillaster possesses a flaw in its lower centre, whereby some of the flower-bases are exposed.

A. (*Cinnyris venusta* var. *niassæ*, Reichw.) is evading a flower's natural opening by an approach from above; in actually entering, the bird commonly hangs boldly out, showing its legs, and is thereby probably enabled to probe well in.

B. (*Cyanomitra olivacina*, Gadow) is entering by an artificial opening a flower with exposed base.

C. (of the same species) is about to enter a convenient flower by its natural opening.

Fig. 5. Section to illustrate the plan of the verticillaster of *Leonotis mollissima*, Gürke; mutual protection by close massing.

(Figs. 1, 2, & 3 were drawn from the actual flowers damaged or visited, freshly picked.)

PLATE 32.

Fig. 1. To show size and position of a flower of *Gardenia tigrina*, Welw., relatively to an approaching *Cinnyris chalybæus*, Shelley. Obviously the natural opening is out of the question. The usual puncture is shown.

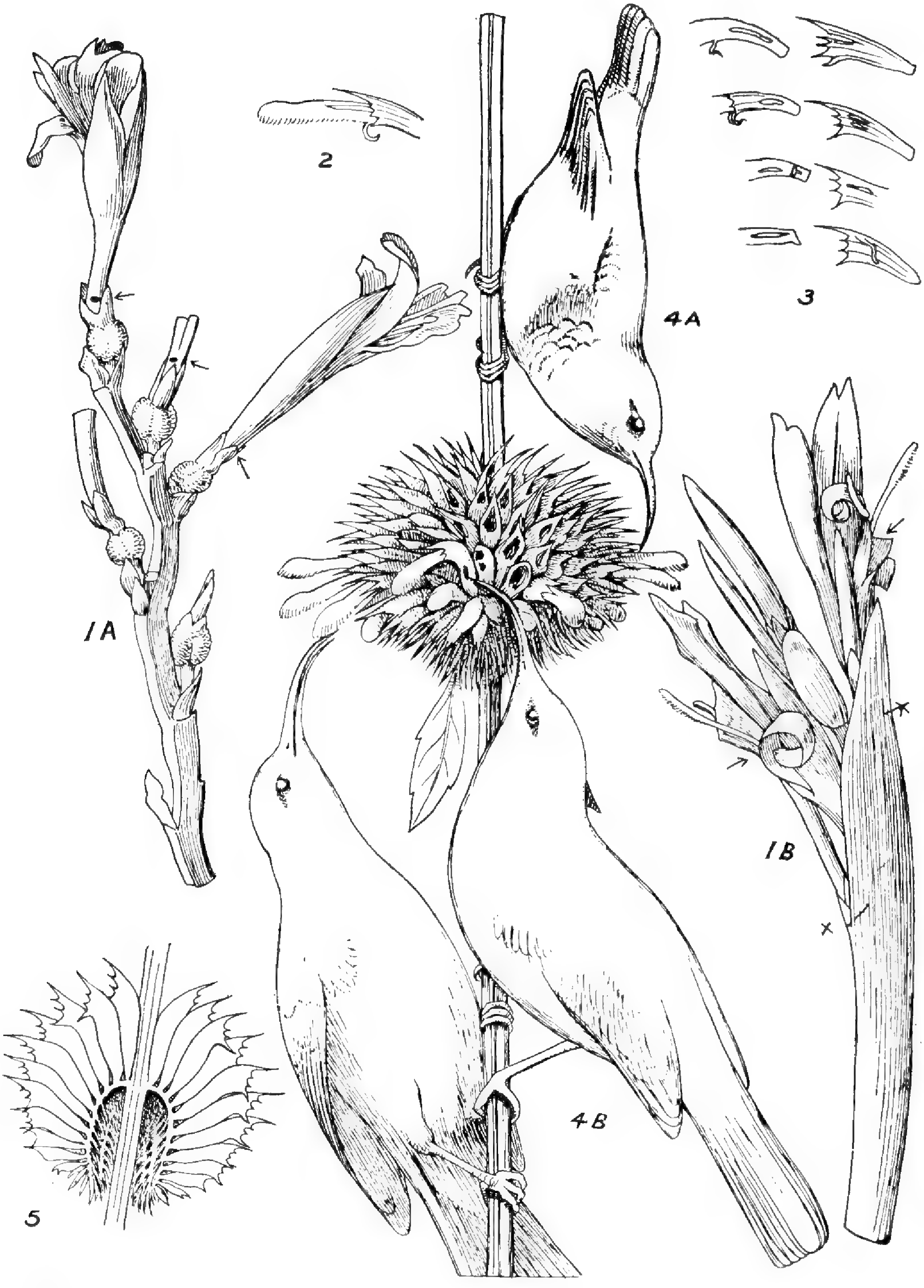
Fig. 2. Damaged flowers of *Kniphofia rhodesiana*, Rendle. *a* shows a slight accidental slit; *b* and *c* deeper ones. *b* and *c* each show punctures (Sunbirds ?, *Xylocopa* ?) of the perianth; *c* and *d*, basal punctures. *d* was drawn from a flower in raceme No. 5, and its injury is typical of others in the same and other racemes with exposed flowers.

Fig. 3. Some of the indirect evidence indicating that a bird was responsible for the damage to *Kniphofia rhodesiana* flowers; see p. 400. The three lowermost flowers were seized together: two of them show the impress of the upper mandible, the lowest that of the lower mandible.

Fig. 4. Racemes of *Kniphofia rhodesiana*, Rendle, to illustrate the "mat" of unfallen perianths.

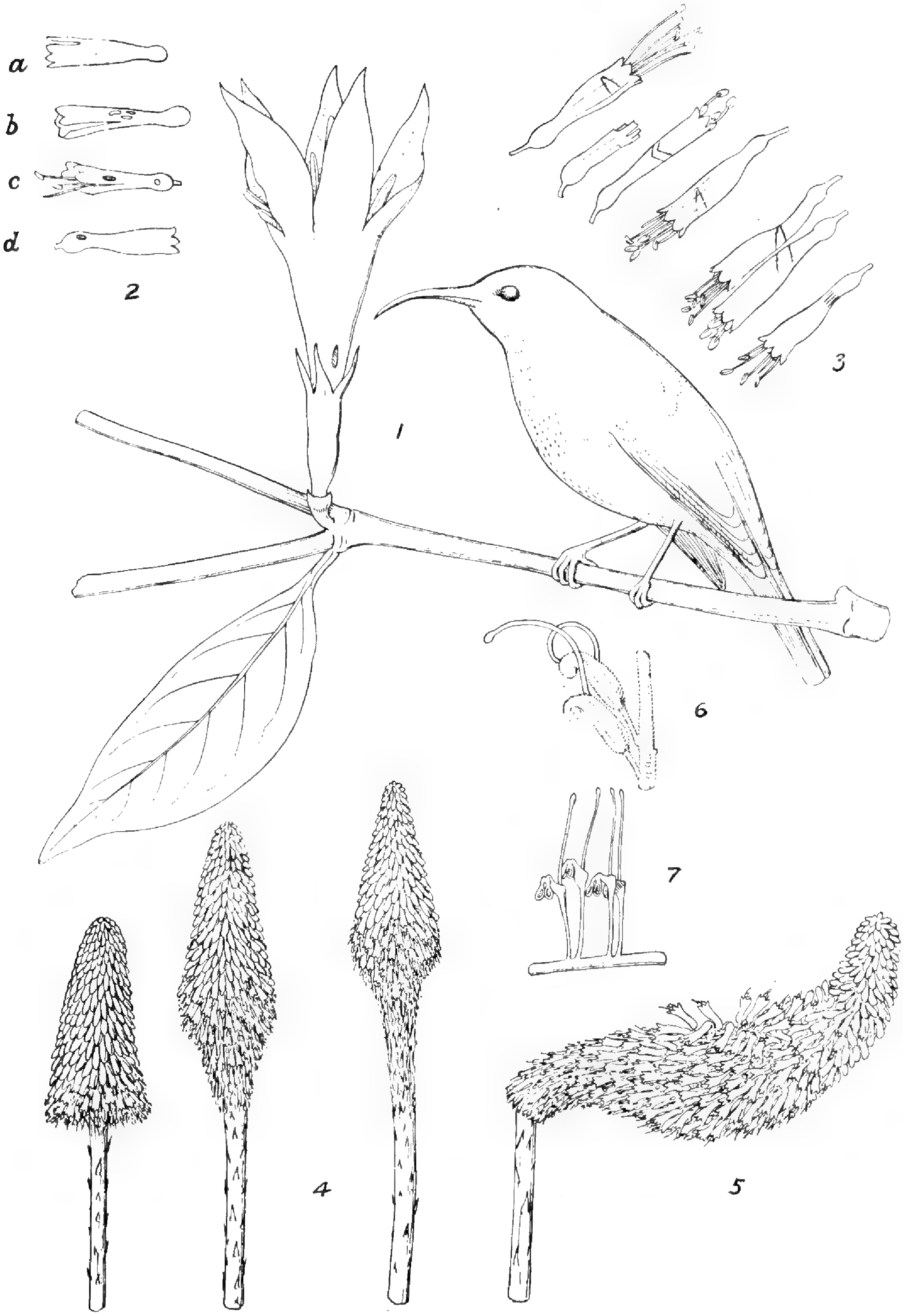
Fig. 5. Raceme No. 1 of the observation of June 3rd, P.M.

Fig. 6. Flowers of *Halleria lucida*, Linn.: protection by pliability.



C. F. M. S. del. Grout, sc.

BIRDS AND NECTARIES.



C. F. M. S. del. Grout, sc.

BIRDS AND NECTARIES.

Short Cuts to Nectaries by Blue Tits.

By C. F. M. Swynnerton, F.L.S.

(Plate 33.)

[Read 18th June, 1914.]

Since writing my paper on "Short Cuts by Birds to Nectaries" in Africa, I have carried out the following observations in Ireland. They seem to show clearly that the Blue Tit, at any rate, is a nectar-eater.

"April, 1914.—In Mr. J. W. Smyth's garden, Duneira, Larne. Noticed Blue Tits that were searching briskly along the boughs and twigs of some Scotch firs, fly down now and then to gooseberry bushes (*Ribes Grossularia*, Linn.) in flower close by, stay there a minute or two only, then at once return to their insect-hunting in the Scotch firs. I had no glasses, and was unable to distinguish the flowers from where I stood, but the actions of the Tits while in the gooseberry bushes were distinctly those of birds that are visiting flowers.

"I then passed on to each of two red-flowering American currant bushes (*Ribes sanguineum*, Pursh), the flowers of which I had previously noticed to have had basal perforations and other damage inflicted on them wholesale, probably by the agency of birds' bills, though possibly by *Bombus*. No birds were now present, and none of the torn-off flower-fragments on the ground below appeared quite fresh. I returned at intervals, and at about the fourth visit found a Blue Tit (*Parus cæruleus*, Linn.) perched in the centre of the bush. I came up close under cover of a fir trunk and watched, and he almost immediately went on to visit the flowers. Where a raceme hung well out, he would sometimes seize its end with both feet and probe the flowers by their artificial openings as he hung there; but he far more frequently perched on the thickest peduncle, or on a neighbouring twig, and, continuing to hold this with one foot, stretched out the other (the left one always while I watched) and seized with it, as with a hand, the tip of the raceme and drew this in towards himself. Then, still holding and steadying it with his foot—hanging in fact from both the peduncle and the end of the raceme,—he rapidly applied his bill to flower after flower, and at once passed on to another raceme. Finally he left. I had been unable to judge whether he actually tore any of the flowers I had seen him visit—in any case very few had not been torn already,—but on going up and re-examining the fragments on the ground, I found amongst them two freshly-severed ones that I had at any rate not noticed before.

"I had, previously to the Tit's visit, carried out a most careful examination of the flowers on the bush with a view to ascertaining whether any of them

contained insects, and I now repeated this examination. Not a single insect, large or small, of any kind whatsoever was found. Nor were any insects visiting the flowers; I ascertained this by watching for a considerable time. It seemed likely, therefore, that it was solely for the sake of the nectar that the Tit had been entering the flowers so assiduously. The weather was, and had been, very unfavourable to insects, and even the hive-bees were not venturing out up to the time of the above observation.

"Later in the day the sun broke through the clouds and brought out a few bees. I saw in all one humble-bee (*Bombus terrestris* *, Latr.) and five hive-bees visiting the flowers of this bush. The former, while I was watching it, took the natural opening every time, even when artificial openings were present. The hive-bees varied. Three of them used mainly the natural openings, and only occasionally came on (and then readily enough used) the artificial ones; the other two, possibly with greater experience of the latter, usually began by entering one or two of the terminal flowers (which were occasionally unpierced) by their natural openings, and then went on to search definitely for and use the artificial openings further back.

"Even now, no other insects visited the flowers or were present inside them.

"The damage consists, for the most part, of perforations (a small segment bitten out) at the bases of the long calyx-tubes. It is present in nearly every flower" (and is shown well in Plate **33.** fig. 2).

"I later visited the gooseberry bushes that I saw Tomtits enter this morning, and found that a large proportion of flowers in each showed what seemed to be distinct bird-damage. In some cases a single bite had been taken out of the side of the cup-shaped calyx-tube; in other cases it had obviously been followed by further bites removing more and more of the lower part of the calyx-tube, but usually still leaving the pistil intact and often even the rim of the tube. In a few cases the pistil had been taken off too.

"In view of the nature of my earlier observation on the Tits visiting these bushes, I thought it would be interesting to test the possible influence of the proximity of cover. The kitchen garden is a long oblong, and the row of gooseberry bushes, running round it about five yards in from its boundary, forms to all intents and purposes the fence to an inner enclosure. On three sides the garden is bounded by trees, on the fourth by nothing but a low, close-clipped privet hedge. Opposite the last, not one of the gooseberry bushes has had a flower damaged; and on a path that runs transversely across the middle of the garden, with no trees near it, only one bush shows

* I collected specimens of all the insects mentioned in this paper, but they were accidentally thrown away. Consequently there is a slight doubt with regard to any that are not readily distinguishable from other common species.

damaged flowers. On the other three sides (including the two long sides) practically no bushes have escaped, except a very few that are as yet only in bud. The damage is worst on the west, where the line of Scotch firs already referred to bounds the garden, rather less on the east, where are scattered hawthorns and lilacs (each just coming into leaf) and a clump of Scotch firs and beeches at each corner, and least on the north, where are quite leafless beeches, smothering in their branches two or three rather poor Scotch firs.

"I watched a humble-bee (*Bombus terrestris*) visiting the flowers. She entered all by their proper openings. Actually she only went up to two pierced flowers, and turned away from each of these; presumably the nectar was drying up as a result of the damage."

"April —. This morning I saw a Blue Tit in one of the gooseberry bushes at fairly close quarters, and watched it. It was not solely after honey, for it twice dropped to the ground below the bush to pick up what may have been a small insect. Then it returned to the flowers and entered many of them, always from the side, with its bill. Some it pulled at, from the side, presumably making the usual hole in them. I found on its departure that a number of the flowers had been freshly opened, I suppose by the bird.

"This afternoon I repeated the observation in another part of the garden. The bird was once more *P. cæruleus*, Linn. I also watched some hive-bees visiting the gooseberry flowers. They occasionally visited pierced flowers, entering them usually by the natural opening, but for the most part they quite definitely rejected such flowers, turning away from them on reaching them. I examined a number of torn and untorn flowers, and found that in the former the nectar supply tended apparently to dry up sooner than in the latter. This would doubtless account for the bees' behaviour. They evidently distinguished by scent. One hive-bee entered a torn flower by its natural opening, but evidently noticing, in moving her proboscis about its interior, the large freshly-made opening in the side, came out of the flower and entered it by this entrance instead. On passing thence to another flower she landed without hesitation on its *side* (ignoring the natural opening completely), and, finding a breach there, entered the flower by it. She went to the side of the next flower, too, but finding no breach she entered it by its natural opening; and of the next two she went *straight* to the natural opening, though there was a perforation in the first of them."

"April —. Saw Blue Tits four or five times in all at the gooseberry flowers early this morning, but they were shy of me, and I found it difficult to approach within effective distance without frightening them off directly or indirectly (through an alarm given by a companion in the trees above). In some cases, at any rate, the birds seemed to search the foliage for insects, as well as entering the flowers. I also saw no definite tearing of the latter.

In one case in which I went down to the gooseberry bushes and examined them after the bird's flight, I assured myself quite definitely that no fresh damage had been inflicted, although the bird had visited flowers, and at least one of the latter afforded indirect evidence that it had been entered by the natural opening. The pistil was pressed to one side and the hairs on its exposed side grazed off, while those pointing inwards from the rim of the receptacle were much damaged and pressed. I found no small insects inside the flowers at this time.

"This evening, however, a good many midges are out, some of them at the gooseberry bushes, and I have made a fresh and thorough examination of the flowers to ascertain if insects could *now* be a partial attraction. None of the intact flowers examined contained anything: their hair barrier must be very effective in excluding small insects. Of the torn flowers, approximately one in fifteen contained a midge that was utilizing the bird damage. This would hardly, one would imagine, be sufficient to induce a bird to go to the trouble of tearing such large numbers of flowers.

"It has been a glorious day—the first for some time past, and the first on which any insects other than hive-bees and humble-bees have put in an appearance. Even such ground-feeders as chaffinches have been taking insects freely on the wing to-day. The red-flowering currant flowers are still attracting nothing but a few hive-bees and humble-bees, but the gooseberry flowers have been attended not only by these (in small numbers), but in the warmer hours by the large yellow flies (*Scatophaga stercoraria*, Meig.) in great numbers and pairing freely, evidently a large brood being just out. These probed intact flowers properly, and are doubtless capable of contributing to their pollination, but they probed torn flowers mostly by their artificial openings. I saw many instances of this on their part, and one or two on the part of a bluebottle fly (I believe *Calliphora erythrocephala*, Rob.-Desv.) that was present at the flowers in small numbers and entered intact flowers properly. The yellow flies seemed not to be attracting birds at all despite their numbers, and from their comparative sluggishness I should think it possible that they may not be altogether a dainty.

"A queen wasp was also visiting the flowers (by the proper opening), and a drone fly (*Eristalis tenax*, Latr., dark form), an excellent mimic of the hive-bee, was resting on a leaf round which three individuals of its model were busily visiting flowers.

"While I was standing on one occasion beside the 'flowering currant' bush (only one remains at all satisfactorily in flower), a Chiffchaff, *Phylloscopus rufus* (Bechst.), perched on an ash twig overhead and dropped thence to the currant bush, but saw me, and at once flew off, so that I could not tell whether it was for the sake of the flowers or not that he had come."

"April 21st.—On the days that have elapsed since I made the above entry I have examined a number of gooseberry bushes growing wild in hedgerows,

as well as those growing near cottages and in friends' gardens. I have nearly everywhere—and at points some miles apart—found the same damage, the chief exceptions being in bushes growing quite close up to cottages. In the garden of my friend Mrs. Johnston of Glynn, three miles away, I confirmed an interesting observation that I have already described. We were examining the currant bushes (*Ribes nigrum*, Linn.) for perforations, and found none. On checking this observation by examining a line of gooseberries alongside, we found none there either. I looked round: no trees. At the end of the gooseberry row (the currants did not extend so far) was a clump of trees, and it was only opposite these that the gooseberry flowers of that row showed damage. Elsewhere, where the garden was bordered by trees, nearly all the bushes had damaged flowers.

"In the same garden were several periwinkle flowers that showed what appeared to be distinct bird-damage at the bases of their corollas, inflicted probably by a rather larger bird than a Blue Tit.

"In all cases I have examined the interior of many of the flowers for small insects and, with the exception already stated, have always failed to find them.

"I have made but few further observations on the birds themselves. A Cole Tit (*Parus hibernicus*, presumably, of Ogilvie-Grant) came down to a gooseberry bush the day before yesterday, and remained in it for three or four minutes before returning, but I was not near enough to be sure it was entering the flowers. Hive-bees, also humble-bees of three species (*Bombus terrestris*, *B. lapidarius*, Latr., and *B. muscorum*, Latr.—the last the least), queen wasps (*Vespa vulgaris*), and two flies (dark *Eristalis tenax*, Latr., and *Calliphora erythrocephala*, Rob.-Desv.) have been regular visitors: of these the drone fly is the least common, but I have on several occasions seen it entering gooseberry flowers either by their natural openings or by breaches, while its model, the hive-bee, in larger numbers, was entering others close beside it. The yellow fly (*Scatophaga stercoraria*, Meig.), so abundant on the first fine day, has also been present, but only to a slight extent despite the continuance of the good weather.

"My continued observations on the attitude of each of these various insects to the damaged flowers have fully confirmed what I have already noted with regard to them. Bees have been on the whole thoroughly content to use the natural opening, and I should not say that the damage inflicted by the birds is likely (except where unusually severe) to be very prejudicial to the fertilization of the flowers under present circumstances—*i. e.*, where bees are in sufficient numbers practically to ensure that each flower will receive visits before the nectaries dry up. I have seen the bees visit by their natural openings even flowers that had recently had their calyx-tube torn nearly right round, its upper rim, carrying the pistils and stamens, remaining nevertheless intact and more or less in position. And

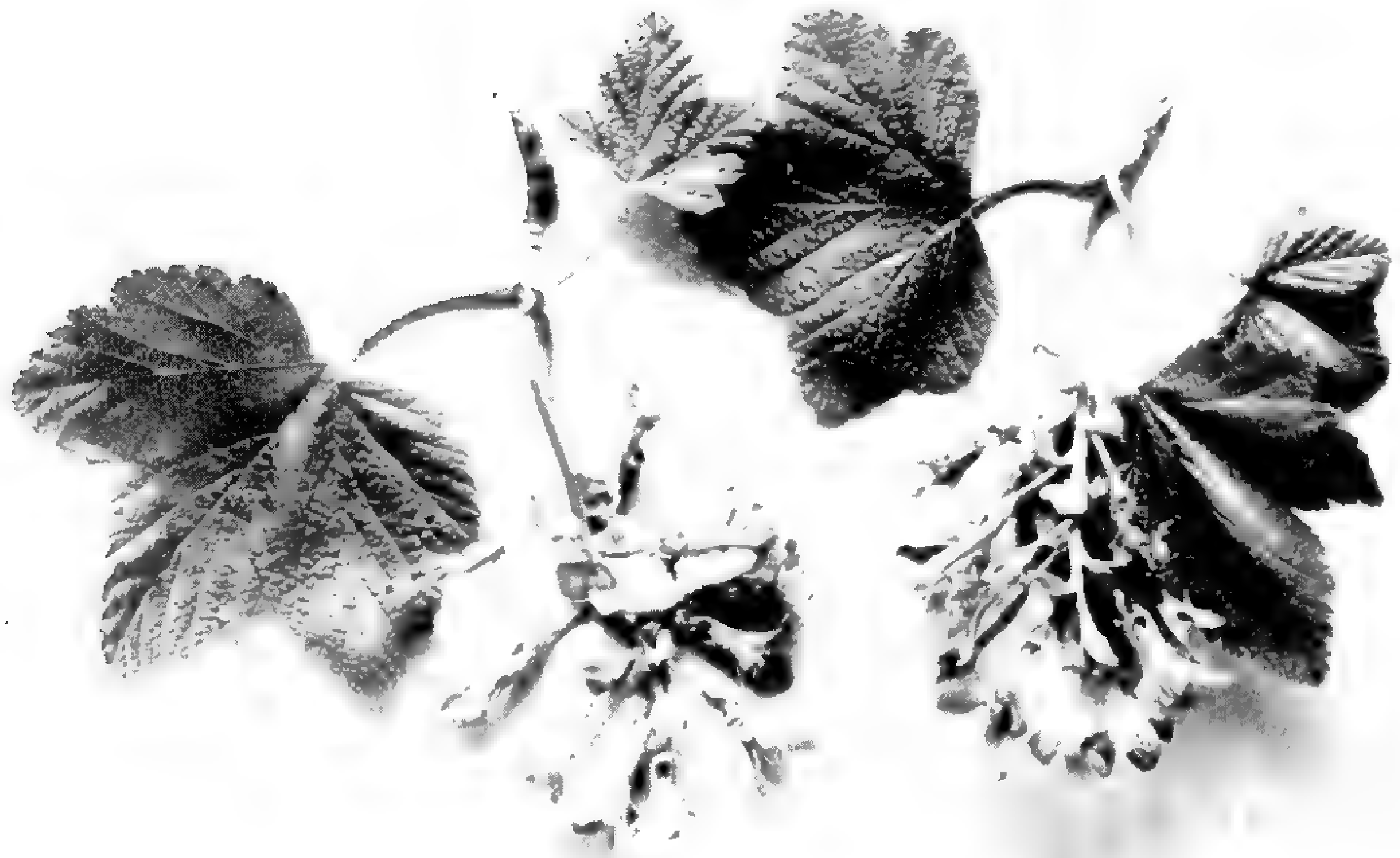
practically all the torn flowers are swelling at their bases as strongly as their untorn neighbours, and show no signs of falling."

It is curious that *Bombus*, a notorious maker of short cuts itself, should in these particular observations have kept so faithfully to the natural openings. That hive-bees for the most part did the same was somewhat in contrast to what has been their behaviour, in so far as I have observed it, in reference to ornithophilous flowers in Africa. It rather tempted me back to a view that was originally suggested by my early observations on *Gardenia tigrina*, Welw.—that at any rate highly specialized entomophilous flowers are likely to be prejudiced less by the short cuts of birds than are highly ornithophilous flowers. In the latter, the greater inconvenience of the natural approach relatively to insects is probably an inducement even to these visitors to use the birds' short cuts.

EXPLANATION OF PLATE 33.

Fig. 1. *Ribes Grossularia* flowers attacked by Blue Tits.
2. *Ribes sanguineum*, flowers with punctures made by Blue Tits.

1



C. F. M. S. phot.

2

BLUE TITS AND NECTARIES.

The August Heleoplankton of some North Worcestershire Pools.

By B. MILLARD GRIFFITHS, M.Sc. (Communicated by Prof. G. S. WEST, M.A., D.Sc., F.L.S.)

(PLATES 34 & 35.)

[Read 2nd March, 1916.]

I. INTRODUCTION.

IN the rather hilly district of North Worcestershire a number of small streams are found. They are tributaries of the Stour or Severn, and run usually in valleys with fairly steep sides. The depth and narrowness of the valleys has made it an easy matter to construct dams, and consequently along the majority of the stream-courses series of artificial pools have been made. In past times the water-power was used to work various kinds of mills, including flour-mills, paper-mills, spinning-mills, and forges. At the present day many of these works are abandoned, and the pools are used chiefly for fishing. In many cases very considerable silting-up has taken place, and thick growths of reeds and water-weeds have been allowed to accumulate.

During the years 1908–1910 a detailed investigation was made of the alga flora of Stanklin Pool, near Kidderminster *. It was thought advisable to examine other pools in the district, for the sake of comparison. In August 1910, collections of heleoplankton were taken from nine pools (including Stanklin) in the Kidderminster district. Seven of these are situated in the basin of the River Stour, and two in the valley of a small stream flowing directly into the River Severn. All these pools lie on the red sandstones of the Trias, and derive their water from those rocks, with the exception of Spring Grove Lower Pool, which receives drainage from the Permian breccia and Old Red Sandstone of Trimpley.

The plankton of the lakes of the British Isles † has been investigated comparatively thoroughly during the last ten years; but little research has been undertaken on the plankton of smaller pools. It will be seen, however, from the results set forth in this paper, that small areas of water often possess alga floras of considerable interest. The pools examined show marked peculiarities in their respective floras. In many cases, also, species

* B. Millard Griffiths, "Algæ of Stanklin Pool, Worcestershire," Proc. Birmingh. Nat. Hist. & Phil. Soc., 1912.

† Consult summary of this in W. & G. S. West, "The British Freshwater Phytoplankton, with Special Reference to the Desmid-plankton and the Distribution of British Desmids," Proc. Roy. Soc. B, vol. 81, 1909.

either rare or not commonly found in the plankton of large lakes were present. As no pool examined had an area of more than twenty acres, true plankton was not found. A large number of forms are derived from the benthos, and forms exclusively found in true plankton are rare.

II. Description of Pools.

1. *Hurcott Pool.*

Area eighteen acres. This pool is the largest and deepest in the district. A strong stream flows through it, and the overflow runs into Podmore Pool, from thence to Broadwaters Pool, and eventually to the River Stour. The water is bounded by open pasture-land on one side and a wood on the other. At the lower end is a strong embankment, on which is a large paper-mill. There are no weeds in the centre, but around the sides and at the upper end there are quantities of *Typha angustifolia*, *Nymphæa lutea*, and *Polygonum amphibium*.

2. *Podmore Pool.*

Area eleven and a half acres. The pool is shallower than Hurcott, and is considerably silted-up at the upper end. It is surrounded by pasture-land. Weeds are rather plentiful; some occur in the middle on a submerged bank. The stream-current is not very marked. *Typha angustifolia* is found at the upper end, and *Myriophyllum* and *Potamogeton* are plentiful round the sides.

3. *Broadwaters Pool.*

Area nine and a half acres. The pool is not deep, and is divided into three parts by embankments, each of which is pierced by tunnels. The water is surrounded by pasture-land and gardens. *Nymphæa* and *Nuphar* are very plentiful.

4. *Island Pool.*

Area two acres. This pool lies in a small stream-course that reaches the River Stour. The water is shallow, owing to silting, and abounds with *Myriophyllum* in every part. The pool is surrounded by fields.

5. *Spring Grove Upper Pool.*

Area half an acre. The pool is one of three forming an ornamental lake in a private park. It is fairly deep. It is much shaded by large trees and is surrounded by grass-land. A little *Polygonum amphibium* occurs on the sides and in the middle. The water is derived from springs and flows into the Lower Pool.

6. *Spring Grove Lower Pool.*

Area seven acres. The pool is long and narrow and has two large

branches. It is deep and free from weeds. It receives its water from two small upper pools and from a small stream coming from the Permian and Old Red Sandstone rocks of Trimpley. It receives a considerable amount of house-drainage. Grass-land surrounds it.

7. *Stanklin Pool.*

Area eleven acres. The upper end is much silted. *Typha angustifolia* and *Arundo Phragmites* occur plentifully round the sides. Banks of *Potamogeton lucens* and *Polygonum amphibium* are found in the middle. An extraordinarily abundant formation of *Chara aspera* covers the bottom of the pool. Most of the pool is shallow, but at the lower end it reaches a depth of ten or twelve feet. The water is surrounded by trees and pasture-land. The water-supply is from bottom springs and from drainage from one or two very small pools higher up. These latter are much contaminated, but their drainage filters through the large bog at the upper end of the pool.

8. *Harvington Hall Moat.*

Area about one acre. It is the old moat of Harvington Hall. It is fairly deep in one part, but about one-third of the original area is completely silted-up. In this mud *Typha angustifolia* and *Acorus Calamus* abound. The water is much contaminated by house-drainage. A small stream supplies the moat.

9. *Wilden Pool.*

Area about nine acres. The water is derived from the River Stour. The pool is fairly deep and comparatively free from weeds. A little *Potamogeton natans* and *Myriophyllum* occurs.

The pools may be classified as follows :—

A. Pools through which a considerable stream flows :

1. Hurcott Pool.
2. Podmore Pool.
3. Broadwaters Pool.
4. Island Pool.

B. Pools supplied by bottom springs or by small streams from adjacent springs :

5. Spring Grove Upper Pool.
6. Spring Grove Lower Pool.
7. Stanklin Pool.
8. Harvington Hall Moat.

C. Pool supplied by overflow from River Stour :

9. Wilden Pool.

III. The August Heleoplankton.

	Hurcott Pool.	Podmore Pool.	Broadwaters Pool.	Island Pool.	Spring Grove Upper Pool.	Spring Grove Lower Pool.	Stanklin Pool.	Harvington Hall Moat.	Wilden Pool.
Temperature, ° C.	15·75	15·75	—	16·5	16·5	18·75	19·0	18·0	—
Bacillarieæ.									
Melosira varians, Ag.	r.	r.	c.	...	r.				
Asterionella formosa, Hass.	cc.	...	...	...	cc.	cc.			
Fragilaria capucina, Desmaz.	...	rr.	...	r.	...	r.			
—— *crotonensis* (A. M. Edw.), Kitton ...	...	...	...	r.					
—— *mutabilis* (W. Smith), Grun.	...	r.							
Cocconema cymbiforme, Ehrenb.	...	rr.							
—— *Cistula*, Ehrenb.	...	...	...	c.					
Cocconeis Placentula, Ehrenb.	...	...	...	c.					
Synedra radians (Kütz.), Grun.	...	r.							
Myxophyceæ.									
Microcystis æruginosa, Kütz.	...	...	r.	rr.	...	cc.	...	r.	
—— *ochracea* (Brand), Forti	...	...	rrr.	...	r.	ccc.			
Merismopedia glauca (Ehrenb.), Näg. ...	...	...	...	...	c.	...	c.		
Chroococcus limneticus, Lemm.	...	...	...	rr.					
Gomphosphæra aponina, Kütz.	...	...	...	rr.	...	...	...	...	rr.
Cœlosphærium Nägelianum, Unger	...	...	r.	ccc.	...	ccc.			
Aphanizomenon Flos-aquæ (Linn.), Ralfs.	...	...	...	...	...	...	...	ccc.	
Anabæna sp. (sterile)	r.								
Nostoc sp. (in small quantity)	...	...	...	...	...	...	...	r.	
Chlorophyceæ.									
Chlamydomonas sp.	c.								
—— sp.	...	cc.							
Pandorina morum (Müll.), Bory	cc.	ccc.	cc.	rr.	...	r.			
Eudorina elegans, Ehrenb.	rr.	c.	cc.	...	...	r.			
Volvox globator (Linn.), Ehrenb.	...	...	...	...	...	r.	...	c.	
—— *aureus*, Ehrenb.	c.								
Pteromonas aculeata, Lemm.	...	...	...	...	rrr.	r.			
—— *ovalis*, sp. nov.	...	...	...	...	...	rrr.			
Glœocystis gigas (Kütz.), Lagerh.	...	...	rr.	cc.					
Scenedesmus quadricauda (Turp.), Bréb. .	r.	c.	...	c.	ccc.	c.	c.	...	c.
—— *bijugatus* (Turp.), Kütz.	...	...	...	...	...	...	...	...	r.
—— *obliquus* (Turp.), Kütz.	...	...	...	...	cc.				
—— *denticulatus*, Lagerh., var. *linearis*, Hansg.	...	c.	...	...	...	r.	...	...	c.
—— *Raciborskii*, Woloszynska	...	...	...	...	...	...	...	...	c.
Oocystis solitaria, Wittr.	...	...	...	c.					
—— *parva*, W. & G. S. West	...	...	...	...	r.				
Lagerheimia sp.	...	...	...	...	c.	rrr.			
Crucigenia rectangularis (Näg.), Gay ...	...	...	...	rr.	...	...	rr.		
—— *reniformis*, sp. nov.	...	...	...	...	...	...	...	...	r.
—— *apiculata* (Lemm.), Schmidle	...	...	...	...	...	...	...	...	rrr.
Tetraëdron caudatum (Corda), Hansg. ...	...	...	...	...	...	...	rrr.	...	r.
—— *regulare*, Kütz.	...	...	...	...	...	...	c.		
—— *minimum* (A. Br.), Hansg.	...	...	...	...	...	...	c.		

	Hurcott Pool.	Podmore Pool.	Broadwaters Pool.	Island Pool.	Spring Grove Upper Pool.	Spring Grove Lower Pool.	Stanklin Pool.	Harvington Hall Moat.	Wilden Pool.
Temperature, ° C.	15·75	15·75	—	16·5	16·5	18·75	19·0	18·0	—
CHLOROPHYCEÆ (*cont.*).									
Tetraëdron tetragonum (Näg.), Hansg. ...	...	...	...	...	rr.	rrr.			
Tetrastrum staurogeniæforme (Schröd.), Chodat	...	...	...	...	r.				
Dictyosphærium pulchellum, Wood	...	...	...	...	...	...	...	...	c.
Pediastrum duplex, Meyen..................	c.	r.	...	...	...	...	...	...	r.
—— *Boryanum* (Turp.), Menegh.	c.	c.	...	r.	ccc.	c.	r.	...	r.
Cœlastrum sphæricum, Näg.	...	...	...	...	...	...	...	...	rr.
—— *cambricum*, Archer	...	...	...	rrr.					
Geminella interrupta, Turp.	...	...	...	cc.					
Staurastrum polymorphum, Bréb.	c.	...	...	...	cc.				
—— *crenulatum*, Näg........................	...	...	...	cc.					
Cosmarium reniforme (Ralfs), Arch.	rr.	...	r.	r.					
—— *granatum*, Bréb.	...	...	c.	c.					
—— *Botrytis* (Bory), Menegh.	...	...	...	c.					
—— *Meneghinii*, Bréb.	...	...	...	r.					
Closterium cornu, Ehrenb.	...	...	...	...	...	rrr.			
—— *Leibleinii*, Kütz.	...	...	rrr.						
Pleurotænium Trabecula (Ehrenb.), Näg.	...	r.							
PERIDINIEÆ.									
Peridinium anglicum, G. S. West	...	...	...	...	...	...	cc.		
Ceratium Hirundinella (O. F. Müller), Schrank	...	...	...	...	...	cc.	cc.		

IV. Distribution of Alga Flora.

As only one collection was taken from each pool, it is not possible to make any general statement concerning distribution. There are, however, one or two points of interest arising out of the observations:—

(*a*) The presence of Bacillarieæ other than *Asterionella* is probably due to the occurrence of weeds, through which the plankton-net was unavoidably drawn. Thus the greatest number of diatoms was collected in Podmore and Island Pools, where weeds were plentiful. The remaining pools were practically free from weeds in the area from which plankton was taken. They yielded no diatoms except *Asterionella*.

(*b*) The presence of *Pandorina* and *Eudorina* in the plankton appears to be correlated with comparative purity of water. It was found that these organisms occurred in pools through which a stream of some strength ran, and which were either surrounded by fields or were of such size that the presence of a few houses would not seriously

contaminate the water. These observations agree with those made in large lakes, where *Eudorina* is a common constituent of the plankton.

(*c*) The presence of *Microcystis æruginosa* and other Myxophyceæ seems to indicate contamination. In the Hurcott series of pools, *Microcystis* was not observed in the two higher pools of Hurcott and Podmore. It occurred in fairly great quantity in the lowest pool, Broadwaters, which is exposed to contamination from the village of Broadwaters. The pool is large and the stream strong, so that the contamination is not sufficiently great to prevent the growth of *Pandorina*.

Spring Grove Lower Pool abounded with *M. æruginosa* and *M. ochracea*. These algæ were so abundant that they choked the pores of the plankton-net in a few minutes. This pool receives a good deal of house-drainage.

Harvington Hall Moat was also very much contaminated and contained enormous quantities of *Aphanizomenon Flos-aquæ*. *Microcystis* occurred only in small numbers in this pool.

(*d*) Spring Grove Upper Pool and Wilden Pool had a dominant Protococcales flora. The former pool is supplied by springs, and is much shaded by trees. Wilden Pool contained the algæ *Crucigenia reniformis*, *C. apiculata*, *Scenedesmus Raciborskii*, and *Dictyosphærium pulchellum*, all of which are confined exclusively to this piece of water. The water-supply is derived from the River Stour, which is here canalized for a distance of about a mile. Numerous barges come up from the Severn at Stourport and down from the Black Country of South Staffordshire, and pass along the canalized river. It is possible that many chance algæ are brought into the water of the pool by this traffic.

(*e*) Peridinieæ occurred in Spring Grove Lower Pool and Stanklin Pool. In both cases *Ceratium Hirundinella* was present, but each pool had its own definite variety of this species (consult Pl. **34**. figs. 16 & 17). *Peridinium anglicum* was found in large numbers in Stanklin Pool.

Summary:—

Dominant Algæ.	*Conditions.*	*Pool.*
VOLVOCACEÆ	Strong stream and little contamination.	Hurcott. Podmore. Broadwaters. Island.
PROTOCOCCALES	Spring or river-water	Spring Grove Upper. Wilden.
MYXOPHYCEÆ	Much contaminated	Spring Grove Lower. Harvington Hall.
PERIDINIEÆ	Slight contamination	Stanklin.

V. Species of Particular Interest.

A noteworthy feature of the heleoplankton collections was the number of algæ that were either very rare or not commonly found. It will be seen from the map that the area in which the collections were made is of quite limited extent, and includes but a small part of the basin of the River Stour. Nevertheless, in spite of the limited area and the single collection from each pool, many algæ previously recorded for solitary spots in the British Isles, or for the Continent, were found to occur sometimes in considerable quantities. Up to the present the majority of collections of phytoplankton have been confined to the sea or to large sheets of fresh water, while many of the smaller pools scattered over various parts of the country have been to a great extent neglected. It seems probable that an investigation of the heleoplankton of small pools over a large area would reveal the widespread existence of many algæ which are now considered rare.

The following species of special interest were found :—

1. Microcystis ochracea (Brand), Forti, in De Toni, Syll. Alg. v. 86. (*Polycystis ochracea*, Brand, Zur Algenfl. der Wurmsees, 1898, p. 200.) (Pl. **34**. figs. 1 & 2.)

Diameter of cells 10 μ ; length of colony may be 120 μ.

This alga occurred in large quantities in Spring Grove Lower Pool. The mucus in which the spherical cells are embedded is highly refringent, and gives each colony a very strongly marked outline. The colonies often attain large dimensions, and are of very irregular form. Each cell contains numerous small dark granules, which are now known as "pseudovacuoles" and were at one time regarded as gas-vacuoles. The organism has been recorded from the Wurmsee, Bavaria, from Lake Varano, Italy, and from Victoria Nyanza, Central Africa. It has not been previously recorded for this country.

2. Pteromonas aculeata, Lemm. in Ber. Deutsch. Botan. Ges. xviii. (1900) p. 94, t. 3. f. 11. (Pl. **34**. figs. 3, 4, & 5.)

Length of cell 20·7 μ, breadth 20·3 μ.

This interesting member of the Chlamydomonadeæ occurred in small numbers at Spring Grove, mostly in the Lower Pool, but a few were found in the Upper Pool. The wing-like prolongation of the cell-wall varies slightly in shape. The cell-wall is ornamented with six rounded projections arranged in two rows transverse to the axis of the cell. When viewed from the side there appear to be three projections, and when viewed along the axis there are two. Four pyrenoids are present. The organism has not been previously recorded for this country. It has been found also in the Stakenbridge Pool, another pool in the Stour basin.

Other members of the genus found in England are *P. angulosa* (Carter),

Dang., from Warwickshire, Surrey, Essex, and Devonshire; *P. Takedana*, G. S. West, from Warwickshire and Surrey; and *P. Chodati*, Lemm., from Great Barr Park, Staffordshire *. In addition, there is a new species, *Pteromonas ovalis*, from Spring Grove.

3. PTEROMONAS OVALIS, sp. nov. (Pl. **34.** fig. 6.)

Cellula ovalis, cum diverticulo parvo cupuliformi in fine posteriori axiali; membrana cellulæ in alam ovalem expansa; chromatophora subcampanulata cum pyrenoidibus duobus. Long. cell. 20·5 μ, lat. cell. 19 μ.

Hab. Associated with *Pt. aculeata* in Spring Grove Lower Pool, Wribbenhall, Worcestershire, but in very small numbers.

This species resembles *Pt. angulosa* (Carter), Dangeard, but differs from it in that the cell-cavity is not pyriform, but is oval with a small cupuliform diverticulum at the posterior axial extremity. The wing is a complete oval, without the prominent anterior angles of *Pt. angulosa*.

4. SCENEDESMUS RACIBORSKII, Woloszynska in Hedwigia, lv. (1914) p. 109, t. 7. ff. 1, 1′, & 2. (Pl. **34.** figs. 7 & 8.)

Length of cell 10 μ, breadth 3·5 μ.

This organism occurred in fair numbers in Wilden Pool. A colony consists of four cells, which are placed so that the longer transverse axes of the cells are arranged radially. When viewed along the longitudinal axis, the cells occupy about one-third of a circle. This species differs from all other species of *Scenedesmus* in this radial arrangement of the cells of the colony. Daughter-colonies of four cells remain for some time attached to the mother-colony. In this respect it resembles *Dimorphococcus*, but differs from that genus in the shape of the individual cells and in the very regular form of the colony.

5. OOCYSTIS PARVA, W. & G. S. West, in Journ. Bot. xxxvi. (1898) p. 335; G. S. West, *l. c.* xxxvii. (1899) t. 394. ff. 14-17. (Pl. **34.** figs. 9 & 10.)

Length of cell 11 μ, breadth 6 μ.

This is the smallest species of *Oocystis*. It occurred in small numbers in Spring Grove Upper Pool. The cells are embedded in a thick mucous envelope, and form small colonies of a few cells. It is a species of rare occurrence.

6. LAGERHEIMIA sp. (Pl. **34.** figs. 11 & 12.)

Cellulæ ellipsoideæ spinis brevibus subcurvatis 3–4 ad polum unumquemque. Length of cell 12 μ, breadth 5 μ.

This alga was found in Spring Grove Upper Pool in some quantity. Mother-cells with four autospores were frequent. The organism does not entirely agree with any described species.

* Consult G. S. West, "Algological Notes.—X.-XIII.," Journ. Bot., l. (1912) p. 330.

7. Crucigenia apiculata (Lemm.), Schmidle in Allgemeine bot. Zeitschr. vi. (1900) p. 234. *Staurogenia apiculata*, Lemm. in Bot. Centralbl. Bd. lxxvi. (1898) p. 151; in Plöner Forschungsberichten, vii. (1899) t. 1. f. 14. (Pl. **34**. fig. 13.)

Length of cell 6 μ, breadth 4 μ; length of colony 15 μ, breadth 11 μ.

A single specimen of this very rare alga was found in a collection from Wilden Pool. Each colony consists of four cells. Each cell of the colony possesses one short broad-based spine, situated on the margin of the free edge of the cell, near to, and slightly inclined towards, the median plane of the colony. The organism has not been previously recorded for the British Isles.

8. Crucigenia reniformis, sp. nov. (Pl. **34**. fig. 14.)

C. coloniis e cellulis 16 formatis; cellula singula coloniæ reniformi; chromatophora cum pyrenoide singulo. Long. cell. 6·8 μ, lat. cell. 4 μ.

Hab. Wilden Pool, Stourport, Worcestershire.

Each colony consists of sixteen cells held together by a rather large amount of mucilage. In the centre of each group of four cells is a small quadrate space, and a large quadrate space lies in the centre of each complete colony of sixteen cells. Each individual cell is reniform in shape, with the exterior curvature lying towards the centre of each quarter-colony of four cells. There is one pyrenoid in each cell. The species resembles *C. triangularis*, Chodat, but differs from it in having reniform cells.

9. Tetrastrum staurogeniæforme (Schröd.), Chodat, Algues vertes de la Suisse, 1902, p. 208. (Pl. **34**. fig. 15.)

Length of cell 4 μ; length of colony 9 μ.

Small numbers were found in Spring Grove Upper Pool, associated with *Pediastrum*, *Scenedesmus*, and *Lagerheimia*. Each cell of the four-celled colony is ornamented with four or five spines, situated on the outer margin of the cell. The alga is of very rare occurrence, and is easily overlooked.

10. Geminella interrupta, Turpin, in Mém. Mus. Hist. Nat. xvi. (1828) p. 329, t. 13. f. 24.

Considerable quantities of this alga occurred in Island Pool. The cells tend to lie in pairs in the filament, but every gradation was observed between paired cells and cells evenly spaced. The filament is invested with a thick mucous coat. This alga is of rare occurrence in the British Isles.

11. Ceratium Hirundinella (O. F. Müller), Schrank, Briefe nat. phys. ökon. Inhalts, 1802, p. 375.

Two forms of this very variable species were found. One occurred in Stanklin Pool. It had three antapical horns well developed and widely divaricated (Pl. **34**. fig. 16). The second form was seen in Spring Grove Lower Pool. It had two antapical horns well developed, but not widely

divaricated, and the third antapical horn was rudimentary (fig. 17). I observed the second form in active movement. It progressed with the apical horn forward, and its path was peculiarly curved.

I wish to thank the following gentlemen for kind permission to take collections of heleoplankton from the pools:—

G. E. Wilson, Esq.	Hurcott and Podmore Pools,
E. Phipps, Esq.	Broadwaters Pool,
T. W. Binyon, Esq.	Spring Grove Pools,
Sir Chas. Holcroft	Stanklin Pool,
Stanley Baldwin, Esq.	Wilden Pool,
W. Westley, Esq.	Island Pool,
E. Hailes, Esq.	Harvington Hall Moat;

and F. Burcher, Esq., for information concerning the acreage of the pools.

I wish also to thank Prof. G. S. West for continuous advice, suggestion, and criticism throughout the progress of the work.

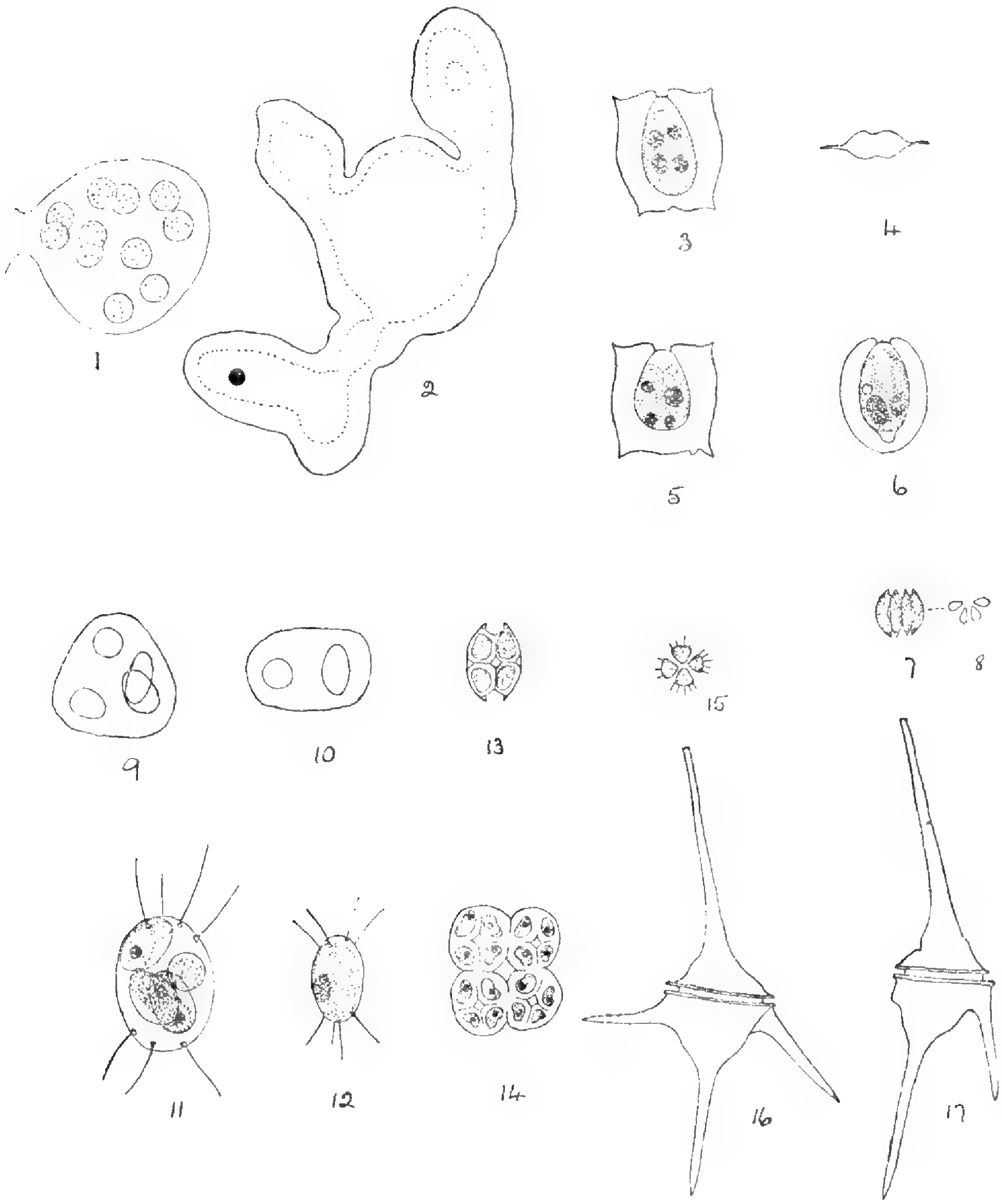
EXPLANATION OF THE PLATES.

Plate 34.

Fig. 1. *Microcystis ochracea.* Portion of colony. × 730.
Fig. 2. ,, ,, Outline of whole colony. × 66. The cells are confined within the dotted line.
Fig. 3 *Pteromonas aculeata.* × 730. Normal form.
Fig. 4. ,, ,, × 730. Axial view, showing rounded projections.
Fig. 5. ,, ,, × 730. Slightly abnormal form.
Fig. 6. *Pteromonas ovalis*, sp. n. × 730.
Fig. 7. *Scenedesmus Raciborskii.* × 730. Single colony.
Fig. 8. ,, ,, × 730. Single colony, viewed along axis.
Figs. 9 & 10. *Oocystis parva.* × 730.
Fig. 11. *Lagerheimia* sp. × 730. Mother-cell with four daughter-cells.
Fig. 12. ,, × 820. Single cell.
Fig. 13. *Crucigenia apiculata.* × 730. Single colony.
Fig. 14. *Crucigenia reniformis*, sp. n. × 730. Single colony.
Fig. 15. *Tetrastrum staurogenieæforme.* × 730. Single colony.
Fig. 16. *Ceratium Hirundinella.* × 132. Form occurring in Stanklin Pool.
Fig. 17. ,, ,, × 132. Form occurring in Spring Grove Lower Pool.

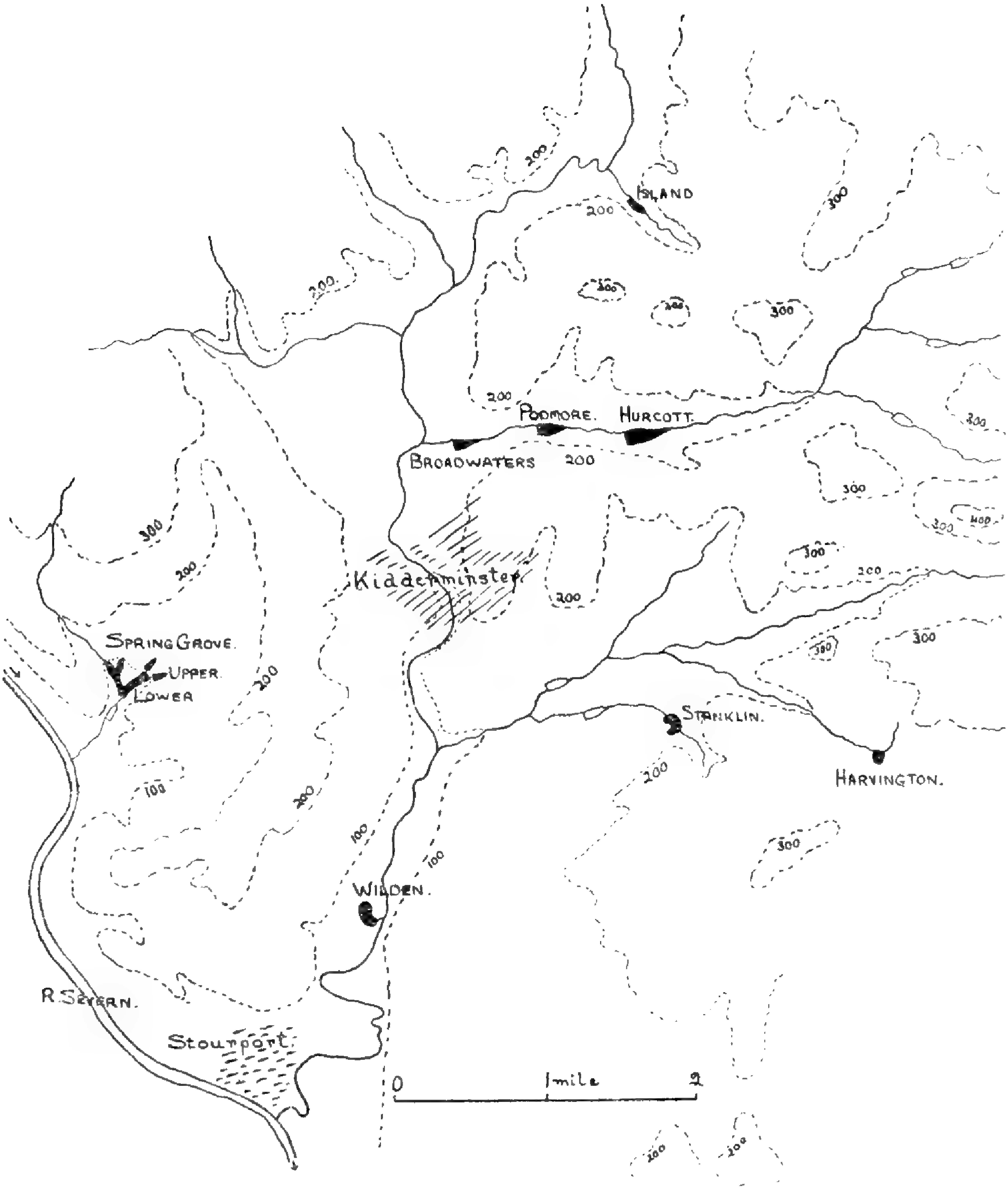
Plate 35.

Map showing the lower portion of the Basin of the River Stour, Worcestershire. Pools from which heleoplankton collections were taken are named.



B. M. G. del.

HELEOPLANKTON OF NORTH WORCESTERSHIRE POOLS.



B. M. G. del.

HELEOPLANKTON MAP OF NORTH WORCESTERSHIRE.

The Seed-Mass and Dispersal of *Helleborus fœtidus*, Linn.

By THOMAS ALFRED DYMES, F.L.S.

(PLATE 36.)

[Read 16th December, 1915.]

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HELLEBORUS FŒTIDUS, Linn., which is known as the Stinking Hellebore, the Bearsfoot, and the Setterwort, is a rare member of our native flora, and in this country is more often naturalized than wild.

Its fruit consists of three follicles, which are often slightly coherent at the base; while the sepals, which persist throughout the fruiting period, enlarge after flowering, and by catching the wind assist the subsequent liberation of the seeds.

Long before maturity the fruit becomes pendent, so that the follicles hang almost vertically downwards. On their dehiscing, a most remarkable state of affairs is revealed and one which is, I believe, unique in our own flora; instead of the seeds being detached singly from the placenta, they break away in one solid mass bound more or less tightly together by a thick continuous ventral strip of succulent tissue, which is of raphal origin. The mass is almost black, whereas the strip when fresh is a shining white; sooner or later it falls out of its follicle and lies upon the ground, and its meaning and subsequent dispersal raise questions of considerable interest.

It has been stated by F. Ludwig—and no one will deny it—that the mass resembles the larva of a beetle; he believed that the ants were deceived by the mimicry, and that they broke it into its constituent seeds, which they then carried off.

Sernander experimented with the separate seeds, and established beyond doubt that the ants take them away and that the white succulent oily tissue is the bait that attracts them: to such baits he gives the name of elaiosome, or "fat-body."

I had seen the plant fruiting on some waste ground close to the Acton Cemetery in July 1899, whence I have no doubt it had escaped, as it was at

that time to be found upon some of the graves there. I then collected a few of the seed-masses, but, although wondering mildly what their significance might be, it was not until the year 1904 that my curiosity was aroused anent their dispersal.

In that year the plant fruited in my garden at West Drayton, and I noticed the masses lying upon the ground, and was again much struck by the larva-like appearance.

It was not possible for me to make any experiments then, and my only note was to the effect that snails break up the mass by devouring the strip, and that I suspected that robins mistook it for a larva and perhaps dropped it some distance away on discovering the deception. This possibility was suggested to me by my finding the broken masses about a yard away from the parent, and by my having disturbed robins in the early morning about the plants themselves.

I have made a few isolated observations since; but I have had the misfortune to lose the whole of my botanical notes for this and some previous years, and it is not safe to quote anything more definite from memory, nor is it, fortunately, necessary to trust thereto now.

In our own country—or, at any rate, in West Drayton—the species, as a rule, ripens but little seed: in 1913 and 1914, for example, it set practically none at all; but this year (1915), owing probably to less unfavourable conditions during the pollination-period, it produced a fair crop, although a great many of the flowers failed altogether, while many others matured only one or two instead of the usual three follicles, and a good proportion of these were by no means up to the average in size or seed-contents.

However, I saw my chance at last, and I decided to make the most of it.

A word may be said here about the pollination, as illustrating the difficulties which beset the species in this country and to which I shall have occasion to refer at the close of this paper.

The plant flowers with me for the most part in January and February, sometimes in December, and occasionally it makes a start quite early in November; it continues to produce blossoms for many weeks or even months, and it secretes plenty of honey in the well-known "jars." It is a curious fact that, just as it sheds the seed-contents of each follicle in a single mass, so with its pollen the contents of each loculus form one coherent lump. Normally, no doubt, these would be carried off by the insect visitors (*Apis* and *Bombus* spp.), but in the horrible weather that we often experience in the early part of the year such visitors are conspicuous by their absence, and the pollen-masses fall out of the anther and may be seen in large numbers as small yellowish lumps upon the leaves of the parent plant. The species is markedly proterogynous, but with the usual overlap; and I fear that with me it has, in most seasons, to depend for

pollination upon purely fortuitous geitonogamy as much as, or more than, upon the insects. It is only occasionally that the conditions offer any reasonable prospect of the normal amount of crossing ; while self-pollination seems to be out of the question altogether, except as the rarest of accidents.

Things are probably different on the Continent, where, according to Sernander, the fruiting period is from the end of July until the beginning of September, whereas with me it began on June 30th and was all over by July 18th. Sernander does not mention the flowering dates, but a delay of a month or six weeks at the commencement of the year would make a considerable difference in the right direction.

But to return to the dispersal. Sernander considered the plant to be myrmecochorous, and in his Monograph, the value of which has been pointed out by Prof. Weiss, he placed it under his *Viola odorata* type ; both of these decisions are, I think, open to question, though we need concern ourselves only with the claim to myrmecochory, for if that cannot be substantiated the other ceases to be of interest.

In addition to my note on the snails and the robins, the elaiosome led me to suspect that the ants play some part in the dispersal, and I was accordingly not surprised at the results obtained by Sernander : what did surprise me was that in his valuable Monograph he makes no reference to the possible part played by birds and more especially by molluscs. I determined, therefore, to investigate these two points, so far as my material would allow, and also to confirm Ludwig's claim that the ants break up the mass by nibbling away at the strip. What follows is an account of the little that I was able to do.

I will first take the agents—Molluscs, Birds, and Ants—in that order, and then discuss the larval mimicry and the claim to myrmecochory.

Section I. Molluscs.

The first seed-mass was dropped on June 30th, and on July 3rd, at 6 P.M., I cleared the ground in front of the plants of all loose seeds and masses for a space of two square feet.

There were three whole masses with the strip still white (Nos. 1, 2, & 3, see Tables), and I shook the plant so as to dislodge any that would be likely to drop during the night. Nine fell to the ground (Nos. 4–12), and I noticed that none of them were broken by the tumble, which may have been as much as 25 inches, the height from the ground of the topmost follicles.

With one exception (see Table I., No. 15), the largest masses that came under my notice (see Pl. 36. fig. 1) contained 14 seeds and measured, in the longest diameter, $\frac{5}{8}$ of an inch, a fair average being 11 seeds and a short $\frac{1}{2}$ inch (see Table I.). The fate of No. 15 was to be badly mutilated by the snails (see Table VII.).

The twelve masses, which I arranged in three rows of four each (see Diagram), contained altogether 133 seeds.

DIAGRAM to show the arrangement and the fate of the 19 masses.

3 July, 1915.	1 (*b*)	2 (*a*)	3 (*b*)	4 (*b*)
	5 (*b*)	6 (*b*)	7 (*d*)	8 (*b*)
	9 (*a*)	10 (*a*)	11 (*d*)	12 (*c*)
4 July, 1915.	13 (*b*)	14 (*d*)	15 (*b*)	16 (*d*)
	17 (*c*)	18 (*b*)	..	19 (*c*)

Fate........	(*a*) =	intact	3
	(*b*) =	broken	9
	(*c*) =	missing	3
	(*d*) =	reduced to single seeds	4
			19 masses.

At 11.30 P.M. that evening one *Helix aspersa* was feeding upon the strip of one mass (No. 3 of 9 seeds) and one *Helix rufescens* upon another (No. 9 of 12 seeds), and the next morning (July 4th, at 10.30 A.M.) three of the seed-masses were broken into two portions: one of these was the one attacked by *Helix aspersa* the previous night (No. 3 of 9 seeds); the other broken ones were No. 1 of 14 seeds and No. 6 of 12 seeds, both of which had presumably been visited by the last-mentioned species. Five seed-masses had been nibbled at one end only, and had lost from one to three seeds apiece. Three were still whole: one of these was the one that had been attacked by *Helix rufescens* (No. 9 of 12 seeds in the Tables, and No. 4 in the Plate). Two others bore no traces of having been visited; they were No. 2 of 12 seeds (Pl. **36**. fig. 5) and No. 10 of 14 seeds (Pl. **36**. fig. 1).

This accounts for 11 out of the 12 masses, and the 12th was missing altogether, nor could I find it, although I searched carefully for it; it was No. 12 of 9 seeds. It should be noted that it disappeared from one end of the last row.

At 5.30 P.M. there was no change; the three conspicuous untouched masses were still in the same position.

The weather had been very dry, and by way of attracting the snails

I watered the ground gently, and shook seven more masses from the plant; these contained 76 seeds, making in all 19 masses and 209 seeds to account for. These seven masses made one more row of 4 and another of 3.

At 10.30 P.M., still on July 4th, there were three *Helix aspersa* and one *Helix rufescens* eating the strips; at midnight there were seven of the former and one of the latter, all busily feeding, and I regret that I did not notice whether the *Helix rufescens* was still on the same mass as before. There was at this time one large worm busy with a portion of a mass composed of three seeds; he was evidently either eating or trying to drag it into his burrow. I noticed this with peculiar satisfaction; for on previous occasions I have found worms feeding upon the more or less succulent capsules and seeds of the snowdrop (*Galanthus nivalis*) and the large soft berries of *Arum italicum*, and I have subsequently found the remains of the berries and the seeds of the latter plant inside the burrows.

On the morning of July 5th, at 7.45 A.M., two more masses had vanished, which, with the one missing the morning before, makes three altogether: the two newly missing ones were No. 17 of 11 seeds and No. 19 of 10 seeds. Here, again, they disappeared, whichever way we look at the diagram, from the end of an outside row; and this curious little point may be of some significance, as we shall see when we deal with the Birds. Three seed-masses were still intact; as they were the same three as were left over the morning before (Nos. 2, 9, and 10, of 12, 12, and 14 seeds respectively), probably the snails preferred the fresher ones.

At 7 P.M. the same evening the position was unchanged; the three whole masses were still *in statu quo*: they were exactly where I had placed them originally, and this is of some importance, as will be clear in the next Section.

I then proceeded to collect all the remains of the 19 masses and 209 seeds, and I have tabulated the results of these observations.

On July 6th and 7th I left the plant alone, and it dropped a few more masses which were duly broken up by snails; but I kept no further record of the numbers. In the evening and during the night of July 7th rain fell heavily, and all the seeds were washed to the edge of the border. This journey was no doubt facilitated by the slope of the ground, and the contribution of rain-runnels to short-distance dispersal is, I am sure, pretty considerable for this and innumerable other species.

It is perhaps just worth mention that here, and on subsequent occasions in a different part of the garden, where I experimented with the ants, I have seen the small black garden-slug (*Arion hortensis*) feeding upon the strip in the same manner as the snails; so that we have three distinct species of molluscs acting as disintegrating agents, but not all to the same extent.

It is true that I did not watch the snails break up the masses in the open; but I do not think that any other visitors can have done so, because when I left masses exposed for the birds, and took steps to protect them from the molluscs, they were not disturbed at all. Furthermore, as will presently appear, I proved by means of captives that *Helix aspersa* can do this work and is a very efficient disintegrating agent; that, however, is a very different thing from effecting dispersal—a point which will receive some little attention almost at once.

Tables to illustrate the work of Helix aspersa.

Table I.—Masses put down.

		No. of seeds.
3.7.15.	No. 1	14
	2	12
	3	9
	4	11
	5	10
	6	12
	7	8
	8	13
	9	12
	10	14
	11	9
	12	9
	12 masses.	133 seeds.
4.7.15.	No. 13	12
	14	10
	15	15
	16	7
	17	11
	18	11
	19	10
	19 masses.	209 seeds.
	Average	11 seeds apiece.

Table II.—Masses intact.

	Seeds.
No. 2	12
9	12
10	14
3 masses.	38 seeds.

Table III.—Masses broken.

	Seeds.
No. 1	14
3	9
4	11
5	10
6	12
8	13
13	12
15	15
18	11
9 masses.	107 seeds.

Table IV.—Masses missing.

No. 12	9
17	11
19	10
3 masses.	30 seeds.

Table V.—Masses reduced to single seeds.

No. 7	8
11	9
14	10
16	7
4 masses.	34 seeds.

TABLE VI.—Summary of Tables II., III., IV., and V.

Masses	II. Intact	3.	Seeds	38.
	III. Broken	9.	„	107.
	IV. Missing	3.	„	30.
	V. Reduced to single seeds	4.	„	34.
Masses 19, seeds 209: as in Table I.				

TABLE VII.—Reconstruction of broken masses in Table III.

	Seeds. *Cohering.*		*Single.*		
No. 1	13	0	1	=	14
3	5	2	2	=	9
4	10	0	1	=	11
5	9	0	1	=	10
6	10	2	0	=	12
8	7	3	3	=	13
13	5	3	4	=	12
15	9	4	2	=	15
18	10	0	1	=	11
9 masses.	78 +	14 +	15	=	107

TABLE VIII.

Loose seeds collected	41
Used for reconstruction (see Table VII.)	15
Leaving	26
Wanted for Table V.	34
Missing seeds	8

TABLE IX.—Possible fate of the missing seeds.

Probably taken by a worm	3
Possibly taken by worms or dispersed wholly or partly by *Helix aspersa*	5
Total	8

The numbers enclosed in the last column but one of Table VII. represent the seeds that I had to take from the loose ones to complete the masses, but which I could not feel sure belonged to any particular one; after such reconstruction I ought to have had 34 seeds left over, but as a matter of fact there were only 26, so that 8 have still to be accounted for. Three of these, which possibly came from mass 8 of 13 seeds, were, I suspect, carried into its hole by the worm; but I cannot speak definitely, because I could not find them there. The fate of the other 5 has still to be discovered or conjectured. The worms may have been responsible for them too, or, despite my search, I may have overlooked them; but there are other possibilities, and one of them was suggested to me by a previous experience of my own.

I have noticed snails in the garden at night with seeds of the Stock sticking to the body; but these are light, thin, and flat, and very different from the ovoid ones of the Hellebore, with which they compare favourably when one comes to the possibility of molluscan dispersal. Moreover, a single seed of the Stock could quite well finish its first flight from the siliqua by alighting on the body of a snail, whereas for *Helleborus fœtidus* this is impossible; it would have to get there from the soil, after the disintegration of the mass. I did my best to witness an instance of its having done so in the open, but I did not succeed, and so I had to be content with experiment, and with proving the possibility of transport if it did get there.

For these purposes I employed captives. I confined a snail (*Helix aspersa*) under a glass jar on a plate; I provided him with a leaf of a *Chrysanthemum*, which is, I know, a molluscan tit-bit, and I also gave him two seed-masses. I took care to cover the plate with earth, as I have found, when experimenting with ants and the fruitlets of *Geranium Robertianum*, that the slight irregularities of the soil, especially when it is dry, are of no small account.

The next morning (July 9th) the snail had eaten the whole of the leaf with the exception of the midrib, and had mutilated the masses, one of which was in three pieces; as neither of them had been reduced to single seeds, there was of course no evidence of dispersal, and all I could conclude was that the snail found both the leaf and the mass palatable. The first night was therefore barren of results, so far as the evidence I was seeking is concerned.

The same evening I replaced both masses by fresh ones. Now, I know that this snail will not eat Violet-leaves except when hard up for food; so I thought that, as I was desirous also of discovering its likes and dislikes, I would take the opportunity of seeing which of the two my captive preferred. I therefore put a single leaf of *Viola odorata* under the glass jar with the two masses.

At 10 P.M. the snail was on the top of one mass; at 11 P.M. this was

broken, and the foot of the snail covered most of the seeds. I watched it crawling over them, and I saw one of them which was on the edge of the snail's body dragged for a short distance before it got free from the tail end.

At midnight I looked at the snail again: he was eating the other mass, and there was one seed on the body, on the median line and close to the edge of the shell on the head side. I was unlucky in having missed the critical moment, for the seed was not there about half-an-hour previously.

By the next morning the snail had broken up both masses and had devoured a portion of the Violet-leaf: he had confined himself to one side of the midrib and had eaten about a third of the way up from the base—*i. e.*, a good half of that side; but the point of immediate interest was that one seed was sticking to the top of the glass jar $5\frac{1}{2}$ inches from the soil and an inch or more away from the now resting snail.

In the evening I removed the Violet-leaf, and left the snail with only the remains of the two masses and one additional fresh one; and at 11 P.M. it was eating the strip of the fresh mass. I hoped that if I kept it short of food it might wander about; and I was not disappointed, for at 7.40 the next morning there were, in addition to the one sticking to the top of the jar, three other seeds on its side at various levels.

Apparently my snail had been more hungry than he liked, for, whereas on the first two nights, when he could make up with *Chrysanthemum* and Violet leaves, the masses were not reduced altogether to single seeds, on the third night no two seeds remained attached to one another and all of them had been completely stripped of the elaiosome.

It looked therefore as if the snails might carry these seeds about, to the extent of a few inches at least, for I could think of no other possible explanation of those on the top and the side of the jar; but I was a little uneasy about drawing conclusions, and I still am, for it is quite possible that the side of the jar, instead of the irregularities of the soil, may have been responsible for the seeds getting upon the body of the snail. One cannot reckon upon such things in nature, although it is tempting to assume that an erect stem, or a conveniently placed stone, in the open may have taken the place of the side of the jar. I had therefore to leave this point undecided, to my regret. It still remains to be proved that the seeds get upon the snail's back without artificial assistance.

I was, however, more successful in proving the possibility of short-distance dispersal if they do get or are placed there. I made several trials with another captive, and I got so interested that I was up more than half the night of July 31st. It is sufficient to say that the creature resented a seed being put upon its tail, and very soon sloughed it off; it was equally touchy about its head and the parts thereabouts, but it seemed quite unconcerned if one were placed on the body near or against the edge of the shell on the

head side. I am, however, too ignorant of molluscan anatomy to explain the reason. Thus burdened, it crawled in a straight line for some minutes, but at last, after covering 14 inches, it had to turn ; that caused the seed to slip, and it was left behind on the newspaper on which I had the snail, having been carried a distance of 18 inches altogether : it took the mollusc just over ten minutes to cover this distance—a somewhat slow rate compared with that registered by Sir Herbert Maxwell ; it wasted some time, however, in turning the corner.

In its wanderings it happened to pick up a fruitlet of *Geranium Robertianum* ; I did not know it was there, but I had been experimenting on the same paper with this species a few days previously. The fruitlet was caught by the threads, and the snail did not get rid of it at all. Out of curiosity, I prodded him with the point of a pencil until he retired completely into his shell, and in doing so he shed a Hellebore but not the *Geranium* seed ; it was still quite close to the edge of the shell when he began to wander again. Subsequently I set him free, and it was still on his body, where it had been for at least twenty minutes.

In dealing even with short-distance dispersal, a matter of a few inches may seem hardly worth recording at all ; but nevertheless, and I do not speak at random, it is a valuable contribution to that local dispersal with which we are now concerned. I have long ago come to the conclusion that for any given species dispersal is, as a rule, a question of several agents rather than of one ; and *Helleborus fœtidus* appears to be so little in harmony with its environment here that, when trying to understand its life-history, one cannot afford to ignore even such a trifle as this.

Six inches a year in all directions from a given point would in ten years account for a circle with a diameter of 10 feet and an area of 78·6, and ten years is but a moment in the life of a species ; if we allow the 18 inches, the distance I saw the seed carried, then the area at the end of ten years would be 707 square feet, or roughly a square 9 yards each way, allowing nothing whatever for other agents, which, with *Helleborus fœtidus*, would most certainly be a very great mistake. This is a contribution which, as such, is not to be despised, and, as a matter of fact, I have watched snails on my gravel-path travel as much as 6 yards or 18 feet in a straight line without a break in order to secure a dainty put down for the birds.

I do not for a moment imagine that one can legitimately consider the point proved ; but it is perhaps reasonable to think of *Helix aspersa* as a possible contributor to the dispersal of the seeds, in addition to being a very efficient disintegrator of the mass. Observation later on will perhaps supply the proof of what experiment suggests. Meanwhile, *Helix aspersa* goes the pace at the rate of 2 inches a minute, or a mile in 22 days, and, but for this unproved point, it certainly may be that some of the missing seeds were carried by them away from the 2-foot square area that I used.

As already hinted, the question presented itself to me whether the masses really attract the snails or are eaten merely because they come in their way, and I took the following steps in order to secure some evidence upon this point.

I cleared the snails out as far as I could—and, I believe, completely—for about a yard all round the plants, and the number I removed was astonishing, especially from an ivy-clad wall behind the Hellebores, which bounded the area in that direction. I then examined the plants themselves and found that there were three snails sheltering in them, and, what I had not noticed before, that some of the immature follicles had been nibbled through and the developing strips eaten—so I left these three, to see if I could catch them in the act. This was on July 11th. I shook three fresh masses from the plants and placed them on the ground. At 9 P.M. one snail was feeding on an unripe follicle. I cannot help admiring the strength of the molluscan stomach; for, in handling these fruits to examine the immature elaiosome, I made my fingers so sore with the acrid juice that they smarted for three days afterwards, and the skin of my thumbs was killed and subsequently peeled off. I went out again the same evening at 9.30: the snail was still feeding, and there were two others on the ground close to the base of the plants. Believing them to be the other two which had taken shelter therein, I removed all three, so as to be sure that any later visitors must come from a greater distance. At 11 P.M. there were none, but at midnight one snail was feeding on one of the masses and there were two more on the ground a few inches off. At 7.45 the next morning two of the three masses were broken up into single seeds, but the third was intact. These snails were old ones, and I do not think that I could have overlooked them if they had been in the cleared area before dark.

By way of getting more evidence, I turned again to my captive. I already had some reason for thinking that there was not much to choose between the *Chrysanthemum*-leaf and the Hellebore's elaiosome, but that he preferred the latter to *Viola odorata*. Now, in addition to the Ivy, the plants growing in the border within the square yard are a perennial *Helianthus* (of which *Helix aspersa* is very fond), *Tropæolum majus*, *Primula vulgaris*, *Coronilla varia*, *Ribes aureum*, *Circæa lutetiana*, *Potentilla atro-sanguinea*, a perennial *Solidago*, *Bellis perennis*, and *Buxus sempervirens*. From previous experiments I know that snails will not eat Ivy, that they do not touch Primrose-leaves unless they be pretty old ones and food scarce; neither will they eat *Circæa*, perhaps on account of its raphides, nor yet the Box, even if there be nothing else.

On the first night (July 12th) I gave my captive a sample of all these plants, and I added one *Helleborus* mass. At 11.15 P.M. it had eaten part of the *Tropæolum*-leaf and part of the *Helianthus*-leaf. I watched it until midnight: it went from the *Helianthus* to the Hellebore and then back to the *Tropæolum*, and when I went to bed it was again on the seeds. The next

morning there was no *Tropæolum* left; most of the *Helianthus*-leaf had been eaten too, and the seed-mass was broken, but not into single seeds.

The next night I gave it a fresh supply of the leaves it had left untouched and another fresh seed-mass, but no *Tropæolum* or *Helianthus*. At 10.20 P.M. it was at the *Helleborus*; it then went to the Daisy, from there to the *Potentilla*, and back again to the seeds, where I left it at midnight. By the next morning it had just nibbled at the Primrose-leaf, a middle-aged one; it had taken about half an inch from the *Solidago*, and had broken up the seed-masses into single seeds.

On the 14th, as I did not want to starve it, but to discover its preferences, I gave it more Daisy, *Potentilla*, and *Solidago*, and more Hellebore seeds. It went to the seeds first, and during the night it again had a bite out of the same leaves as before, but evidently the *Potentilla* was not relished.

The next night I reduced it to *Ribes*, *Circæa*, Ivy, *Coronilla*, and Box—the things it had, so far, refused to touch,—and I added one more seed-mass. It fed upon the seeds and nothing else for four nights on end, although I kept the supply of leaves fresh. On the fifth night I relented, and gave it another seed-mass, two small *Chrysanthemum* leaves, and a young *Tropæolum* leaf. It ate the bulk of the banquet, and next morning there was nothing left on the plate but the débris of the leaves and the seeds of the Hellebore, now stripped clean of the bait.

There is, then, I think, some reason to believe that *Helix aspersa* eats the strips because it likes them, for it attacks the immature follicles and gets at them; apparently it will go for them from a distance of a yard or more, and it eats them as readily as it does other foods for which it shows a liking.

Summary of Section I.

Molluscs.—One can say almost nothing about *Helix rufescens*. This snail is comparatively rare in my garden, and I saw but one individual on the masses. The most one can conclude is that, where the two are found together, it will eat the elaiosome; but in my garden it did not apparently succeed in breaking up the mass.

For the slug, *Arion hortensis*, one may fairly come to the same conclusion, that it acts to some extent as a disintegrating agent, although in an entirely minor degree.

Helix aspersa, on the other hand, must be credited with a great deal of execution in this way. It not only can, but it does, break up the mass into single seeds; when short of food, it will strip the latter bare of the bait.

It appears that the seed-mass, or rather its elaiosome, really attracts the snails, though that is not the same thing as saying that it is an adaptation to molluscan disintegration—a point to which I shall refer later.

It also seems possible that this species may carry the seeds some little

distance away from the parent plant, although it still remains to be proved by observation that these seeds get on to the body in the open, instead of being placed there by the experimenter indoors.

Worms.—Possibly these help in burying stray seeds or small bits broken off the mass.

Section II. Birds.

My next object was, if possible, to account for the disappearance of the three whole masses. I searched in vain for them, though it is as likely as not that they were somewhere in the garden.

There is no ants'-nest in the border where my Hellebores grow, nor do I remember ever having seen an ant or a mammal thereabout, with the exception of cats and dogs, although I have kept a look-out for rats and mice; so it is difficult to avoid thinking that their disappearance is perhaps to be attributed to birds.

When the masses are fresh, the broad white strip stands out boldly against the black margin by which it is surrounded, and they frequently—I think I may say generally—fall in such a manner that the elaiosome is plainly visible from above, a point that should be noted carefully when one is dealing either with birds or ants. When the masses are stale they are not so conspicuous, for the strip turns at first a light and afterwards a darker dirty brown.

I have frequently noticed robins about the plants in the early morning and suspected that they may have been after the masses, but I have never been able to justify that suspicion.

In addition to this bird we have thrushes, blackbirds, sparrows, hedge-sparrows, starlings, wrens, and some others as occasional visitors, such as bullfinches, chaffinches, whitethroats, and very rarely a nuthatch. The thrushes are rather fond of this border, and I have disturbed them at various times of the day quite close to the Hellebores. In the early hours of July 5th one of them was on the bed in which they grow, not more than half a yard off, and I watched it to see if it would take one of the masses lying on the ground, but it went right over them, extracted a snail from the ivy on the wall, and proceeded to smash it with the usual vigour on the tiled path close by. Subsequently between the 6th and the 14th I placed perfectly fresh seed-masses in twos and threes in various parts of the garden; I laid them on the soil with the strip uppermost, and they were very conspicuous against the brown earth, but not one of them was removed.

Altogether I put down four lots of 3 each and three lots of 2 each—that is, 18 masses in seven different places. My plan was to place them in position about midnight, so as to catch the early bird, but on the first occasion I caught the late snail instead, for the first lot of three was badly mutilated by the next morning. I thought of protecting them with a ring of powder, which I know from experience neither snails nor slugs can cross, but I feared

it might have the effect of deterring the birds too, so I had to choose favourable places and clear away the molluscs first; by this means I managed all right, and the masses remained undisturbed until, when the strips had turned brown, I removed them myself, after some of them had been there for a week; they had become very fragile and some of them broke at a touch, despite my efforts and desire to keep them whole. Thus, ignoring the first three masses, which were spoilt by the snails, the remaining fifteen were left severely alone by the birds during the whole period of observation.

Summary of Section II.

In the face of this evidence, and in view of the fact that over a period of ten years or more I have never seen a seedling more than about a yard away from the parent plants, one can hardly maintain that the larva-like appearance is an adaptation or has any real dispersal value as far as my birds are concerned.

On the other hand, I admit that I am still suspicious, for it is hard to account for the disappearances except by their agency, and I am inclined to think that they may be deceived at first but soon learn their lesson.

In my own garden and neighbourhood the seed-masses must be unfamiliar objects, if not altogether unknown to the birds; there are such things as young and inexperienced birds and birds of an inquisitive nature, and, as a matter of fact, the only masses that disappeared at all, while these observations were in progress, vanished during the first two days, presumably before the birds had had time to get used to them. The curious little point that, whatever the agent, the mass was in each case taken from the end of a row lends support to the view that cautious curiosity, soon satisfied, may have had something to do with it: a glance at the diagram will show that it was not only from the end of the row, but, on both nights, from the lowest or outside row. Again, as I have already mentioned, the fall from the follicle does not break the mass, whereas those that I found some years ago were smashed, and this suggests a fall from a height greater than 25 inches.

On the whole, while denying any adaptational mimicry on the evidence adduced by me, one may, I think, admit the possibility of occasional dispersal by birds during the first few days of the fruiting-period.

Section III. Ants.

There remains the question of the part played by ants. In this matter I was unfortunately at a disadvantage in two ways—my supply of fresh masses did not hold out long enough and the fine weather broke up, rain falling on some days in torrents. The little I was able to do, however, interested me very greatly.

The ants with which Sernander experimented were three species of *Formica*, namely *rufa*, *rufa-pratensis*, and *exsecta* : none of these are, so far as I know, to be found in my small suburban garden, and for the most part I used *Donisthorpea nigra*, which abounds therein, but in a totally different quarter several yards away from the Hellebores and divided off by a fence : I also tried my luck with *Donisthorpea flava* and *Myrmica lævinodis*, and obtained results of some little interest, especially from the latter species.

I must take this opportunity of acknowledging gratefully my indebtedness to Mr. H. St. J. K. Donisthorpe, F.Z.S., F.E.S., for kindly naming my ants for me, and for giving me valuable information about their habits. I have availed myself to the full of his ready and willing assistance in these matters.

On July 9th I gave *Donisthorpea nigra* single seeds, and I found that, like the Formicas, they take them away in a very few minutes. I also saw them carry them into the nest : as the seed is considerably more bulky than the ant this is a performance worth watching, and one that is not altogether devoid of the comic element.

I then offered them a mass as well as single seeds ; they paid some little attention to the former, but soon deserted it altogether for the loose seeds. The next morning the mass was still there, and, although not broken, it was quite brittle and the strip distinctly mutilated. The border is hot and dry, and the strip had turned brown by the evening : there was no trace of its having been visited by snails, and probably the nibbling of the ants and the heat of the sun were responsible for its drying up so soon. This mass was about a foot from the entrance to the nest : the ants paid no further attention to it, and I removed it two days later, when it broke as I lifted it from the ground. I think the ants showed their sense in carrying off the single seeds instead of expending their energy upon the mass.

On July 12th I tried them again with a single mass, which I placed in the same position as the other, and I watched it for an hour between 6 and 7 in the evening, when it was fortunately sunny and the ants were out foraging. It was first attacked by a few of them, and they seemed to appreciate the fare. After, apparently, satisfying their own taste for it, they went off and presently it was receiving the attentions of a large number simultaneously—at one time I counted 14 on the strip. They nibbled away until I left them for dinner at 7 o'clock, and half an hour later they were still at it, but about 8 o'clock it began to rain and get dark and the ants deserted it. They had not broken it up when I went to bed, and I then put another mass about one inch from the entrance to the nest, without, however, having the slightest suspicion that the shorter distance would mean a fresh development.

The next morning the first mass was broken, but I cannot say whether the ants or the rain had done it. The other was a wonderful sight : there

were ants on it and under it and all round it; this was about 7.45 A.M., and at 8 o'clock I went to look at it again, but there was no trace of it to be seen—it had vanished. It had begun to rain again, and, while I attributed the disappearance of the ants, erroneously as I now believe, to the weather, I was at a loss to account for the seed-mass.

The next chance that I had was on July 18th; by this time there was only one mass left upon the plant, but I had several in reserve, and was keeping them as fresh as I could in a damp box. I put down the fresh mass and selected the one with the whitest strip from the box; both were placed about two inches from the entrance. There were only a few ants about, but in a few minutes each of them had its own visitors, and the fresh one was alive with them; about half an hour later it had completely disappeared, and I began to suspect the truth.

Just then I could not watch, so I removed the other mass and replaced it in the afternoon: it was attacked again at once, and this time I meant to see what happened, and, at last, after it had been there for the better part of an hour and I felt quite sure what the ants were about, I saw it disappear into the nest. It required some doing, but by dint of pulling and shoving, it quickly vanished, when once the ants got it into position.

After my supply of fresh masses came to an end, I tried the ants on several occasions with stale ones, fragments, and loose seeds, equally stale or staler, with the result that they will carry off the latter, but, so long as they can find any small bits or single seeds they do not trouble about moving the masses, unless they be placed close to the entrance of the nest, although they nibble away at the faded strip; it almost looks as if they make up their mind that the game is worth the candle before starting upon the onerous business of taking the mass inside. The staleness does not seem to matter, for I have seen masses which were more than a fortnight old disappear into the nest; it makes no difference whether the strip be white or brown, dirty or clean, or whether the mass be placed with it uppermost or undermost, or in any other posture.

After I had satisfied myself that *Donisthorpea nigra* will carry the mass into its nest, I amused myself in watching their performances when the conditions were favourable, and I had the opportunity. During the afternoon of July 31st, when my material was fully a fortnight old and most of it some few days older, I gave them several fragments and finally one mass, which I was careful to place just two inches from the entrance, with the idea of finding out how long it would take them to get it inside. I saw them begin to move it and then I busied myself with removing a few small weeds from the gravel-path. During the fortnight that had elapsed since the 18th the ants had had most of my fragments and loose seeds, and I found several of the latter dropped upon the path, presumably by them. As there are several nests this is merely what one would expect. My attention was,

however, attracted by a worker of *Myrmica lævinodis* carrying off one of the seeds. Up to this moment I did not know that this species was in the garden at all, but I followed her and came upon the nest a few yards away.

Returning to *Donisthorpea nigra*, I found that they got the mass into the nest in almost exactly 40 minutes from the time that they commenced operations ; it was old and soil-stained, and if the larval resemblance is to be attributed to the white strip, it certainly had none at all, for the whole thing was earthy.

By this time I had only one unmutilated mass left ; it, too, was old and dirty, and it happened to be a large one of 14 seeds. I first gave the Myrmicas single seeds and fragments, and they very quickly carried them inside. Finally, I gave them the mass, which I placed three inches from the entrance that they were using. It was attacked by a swarm of workers, but they moved it only with difficulty : more of them arrived and they managed to raise it bodily and get it a little nearer the hole. Then they changed their tactics, many of them went off, and those that were left worked hard at nibbling the strip. In about 25 minutes the mass broke into two and the smaller portion of five seeds was at once taken into the nest. The remainder was again divided in a very few minutes, and the whole mass was thus taken inside in three instalments and in about 32 minutes.

This is the only occasion on which I have seen a mass broken by the ants, and as I had no more left, except those that I wanted to keep for the photo, it is likely to remain the only one for some time to come.

Myrmica lævinodis is a larger ant than *Donisthorpea nigra* and presumably more powerful, and in the result it got the larger mass into its nest in about three-fourths of the time that it took the smaller species to cover only two-thirds of the distance (that is to say, it covered a distance greater by 50 per cent. in a period of time shorter by 20 per cent.), though it is not easy to decide whether it owes its greater efficiency to its superior strength, its different methods, or to both of them ; one must, however, remember that the strip had become decidedly brittle by this time, whereas the fresh strip is more or less tough.

On the same afternoon I also discovered a third species in the garden, namely, *Donisthorpea flava* ; it is considerably smaller than *Donisthorpea nigra*, and seemingly not nearly so energetic. Its worker simply nibbled at the bait languidly, but made no attempt to move the seed, nor was there any combined effort either for the single seeds or the fragments ; in justice, however, one must again remember the staleness of the elaiosome. This species is more subterranean in its habits than the other two, and is largely dependent upon root-aphides for its food ; it milks them and feeds upon the excreta, so it is not perhaps surprising that it did not display anything like the same interest—perhaps it was out of its nest merely to enjoy a sun-bath and some sleep in the open air.

Summary of Section III.

Donisthorpea nigra.—While there can be no doubt that this species disperses the single seeds when it comes across them, my evidence does not show that it disintegrates the mass, and I provided it with fresh as well as with stale ones. We have, however, the fact that when sufficiently close to an entrance-hole it can and does take the unbroken mass into the nest.

Myrmica lævinodis, on the other hand, while behaving in the same way as regards the single seeds and the fragments, will break up a bulky mass, and, in comparison with *Donisthorpea nigra*, it gets it into the nest in considerably less time.

Donisthorpea flava, the third ant, seems to be of little account or none at all so far as stale seeds and fragments are concerned.

Section IV. The Larval "Mimicry."

Presumably no one would suggest that the resemblance to a larva attracts the molluscs, and apparently it does not deceive the birds of my garden—at any rate, to an extent great enough to be of advantage to the species or to justify us in calling it adaptive so far as they are concerned. That, however, is by no means the same thing as saying that there are no birds anywhere to whom the mimicry appeals. A great deal of information and observation must be available before one can pronounce judgment on this point: we ought to know, for example, what larva or larvæ the mass resembles, whether they occur at the right time and place and in sufficient abundance in the natural haunts of the Hellebore to be really familiar to the birds of those parts, and whether the resemblance is sufficiently close to lead to mistakes often enough for one to call the mimicry an adaptation. Hence a great deal of work will have to be done to enable one to entertain an opinion worth expressing upon the interesting possibility of ornithochory.

With regard to the ants, the question whether they are or are not deceived by the resemblance is of some importance for the sake of accuracy, and lest we put *Helleborus fœtidus* into a wrong dispersal-group, although, of course, it would not be the only or even the most important point to consider.

It is notoriously difficult to prove a negative—to establish that the resemblance, when it is there, does not deceive the ants; but, on the other hand, the evidence seems to show that they are attracted all the same when it no longer exists, and that it is the elaiosome that is responsible. It is quite certain that at any rate some species go for the whole mass when it is old, stale, soil-stained, and of a uniform earth-colour—when, in other words, the resemblance has partly or completely disappeared, as far as human perception

is concerned ; neither can there be any doubt that they carry off fragments and single seeds, and also, as found by Sernander, the detached elaiosomes, as well as seeds from which the bait has been removed—attracted, no doubt, in the last instance by the oil-drops remaining upon the testa.

It is true that some ants, including *Formica* and *Donisthorpea*, carry larvæ into the nest, either whole or in bits ; but whatever one may think about the mass, one can hardly believe that they mistake the fragments or the single seeds for parts of a larva, or that they could work upon the mass itself for 32 or 40 minutes without realizing that it was not what they thought it to be.

Personally I am at one with Sernander in disagreeing with Ludwig's suggestion, and especially because it is difficult to see how it operates. One hears about mimetic resemblances so much that is fanciful or forced, if not positively foolish, that one is naturally prone to criticise them pending the production of evidence that is really pertinent and cogent. I admit I am always inclined to look askance at supposed cases, because, among other reasons, it is necessary to be on one's guard against running adaptation too hard. Organisms, as well as things inorganic, must have some form, size, and colour, whether it be of survival value or not—these are among the raw materials with which Natural Selection works, preserving, eliminating, or ignoring, as the case may be ; and it is, to my mind, not reasonable to assume that every chance resemblance, real or imaginary, must be of use to its possessor—that is a trap, about which it behoves us to be very wary indeed at all times.

Such cases as that of our Hellebore—and I know a great many of a similar nature in the world of fruits and seeds—demand a great deal of proving.

It is difficult to believe that ants, which cannot be thought of as wanting in intelligence, would be taken in more than once, unless, indeed, seed-masses and larvæ occur together in time and space and the resemblance is pretty close ; and even if they were deceived they would, one must believe, soon discover the mistake.

Again, it is not easy to decide which of the five senses is to be invoked to attract an ant from a distance, even if it be but an inch or two. Touch and taste may be ruled out at once, because neither of them operates except by actual contact. Smell and hearing are equally hopeless, until we can be sure of the emission of a larva-like odour or sound ; and so, barring the assumption of some unknown sense, which is not a very promising start in quest of a proof, we are reduced to sight, and I admit I have grave doubts whether an ant could see the strip at all until it was upon the mass, especially when it lay, as is so often the case, with the elaiosome uppermost.

Moreover, I do not believe that any additional incentive is necessary

to induce the ants to try their jaws upon a glistening white oleaginous strip whenever they come across one; they find much smaller fruits and seeds than these, possessing baits of one sort or another, that are barely or not at all visible to us.

I am of opinion, therefore, that the larval resemblance, which nobody could deny, is entirely inoperative and superfluous so far as the ants are concerned; that the idea of its deceiving them is erroneous, and that we must not look upon it as an adaptation to dispersal by them *.

Section V. The Claim to Myrmecochory.

I am, however, far from thinking, even if I am correct in the view that I have just expressed, that it disposes of the claim to myrmecochory. That claim could conceivably be maintained on other grounds, *e.g.*, the binding of the seeds into a single mass by means of a nutritious elaiosome. But if we are to consider that the mass is "adapted" in any way to dispersal by ants, we must show, in order to justify the use of that word, that the massing confers upon the species an advantage which it would otherwise be without. Personally I do not see that it is or can be so, so far as the ants are concerned, but rather the reverse.

We have seen the mass taken into the nest whole and in pieces, but I fail to recognize any advantage to the species in either event, unless the work done by the plant in binding the seeds together be undone by the ants, and the seeds subsequently ejected from the nest; and then the massing is but labour lost. The same argument would apply if it could be proved that the ants reduced the mass to single seeds, and then carried them off; it would still be a case of misspent energy on the part of the plant †.

* It is, nevertheless, possible that it may bear a negative instead of a positive interpretation; it might, for example, deter a seed-eater, of one sort or another, from attacking what looks so much more like a larva than like any other fruit or seed in our Flora. But this is, of course, an assumption pure and simple, and, moreover, is one that would have to be tested by experiment: one might, for instance, offer the same bird or other animal first the mass and subsequently the single seeds, and note the response; if the latter were taken and the former left it would suggest a deterrent of some sort, although not necessarily in the larval resemblance.

† The possibility of time being saved in dispersal by the seeds being massed, and so more easily found and carried away ten or eleven at a time, must not, however, be overlooked; but, since the seeds always, in my many trials and in my garden, lie over the whole winter, I do not consider any economy effected in this way a sufficient explanation. Normally, the mass breaks up from weathering in a very few days in the open, especially when hot sunshine alternates with heavy rain, as frequently happens in the fruiting months; and two or three days, or even a week or more, is not a large economy over a period of nine or ten months.

I cannot, therefore, avoid the conclusion that the claim of *Helleborus fœtidus* to myrmecochory is hardly a valid one *.

Final Remarks.

There are a few additional points of interest in the general subject of Myrmecochory and in the natural history of the Hellebore that came before me during this investigation.

For example, the seeds of this species, like those of *Viola odorata*, lie over the winter; and I have some evidence that, for the latter, those seeds whose caruncle has been removed or lacerated are at an advantage compared with those upon which it is left intact. They germinate earlier, which no doubt is not always desirable, but they also produce more vigorous plants, especially as regards the root-system, upon which the seedling depends for food-materials after the cotyledons have expanded. I have therefore sowed some of my snail-stripped Hellebore seeds in a separate pot, to compare the results, when the time comes round, with others from which the bait has not been removed.

Again, it appears that with the Daisy (*Bellis perennis*) the achenes carried into the nest are lost to the species unless they be subsequently ejected, while those that are dropped or abandoned after the elaiosome has been nibbled are the lucky ones. I have therefore left the ground undisturbed where I saw the masses carried in by my two species of ant, in the hopes of interesting developments next spring; for one must remember that, whereas the cotyledons of the Daisy seedling lie practically on the ground, those of the *Helleborus fœtidus* have a hypocotyl fully an inch in length, and may therefore be expected to work their way through a considerably greater depth of soil. I am not, however, at all sanguine; for ants burrow to a much greater depth than an inch, and, if one can judge by the very small percentage of seeds that germinate with me, I am afraid that they ripen imperfectly. In my borders also the snails eat the seedlings greedily; so that the species is hard put to it to hold its own against its many disadvantages, and the observer, to satisfy his curiosity, must possess his soul in patience.

I hoped to throw some little light upon the meaning of the mass—upon the question why the seeds are thus bound together; but I cannot feel that I have done anything of the kind.

Should anyone suggest that the cohesion is an adaptation to the dis-

* "Not proven" is, I feel sure, the fairest verdict that one can return so far, for, until the meaning of the mass is fully understood, the claim cannot be said to be disproved. But dispersal is such a very difficult and complicated question, and one that is so full of surprises, that this species may perhaps be retained in the group with advantage for the present, pending further research and under very grave suspicion.

integration of the mass by molluscs, and the subsequent dispersal of its components by ants, we may well ask why *Helleborus fœtidus* should, so to speak, take all this round-about trouble, whereas its brother in this country, *Helleborus viridis,* in common with many other species of different genera and families, gets dispersed by the same agency without the intervention of the strip, the snails, or the slugs. *Helleborus viridis* adopts the simpler and the usual course of dropping its seeds singly, instead of in a mass ; they are polished, black, and sculptured, and, instead of a great connecting-strip of oily tissue, each of them is provided with an inconspicuous raphal bait.

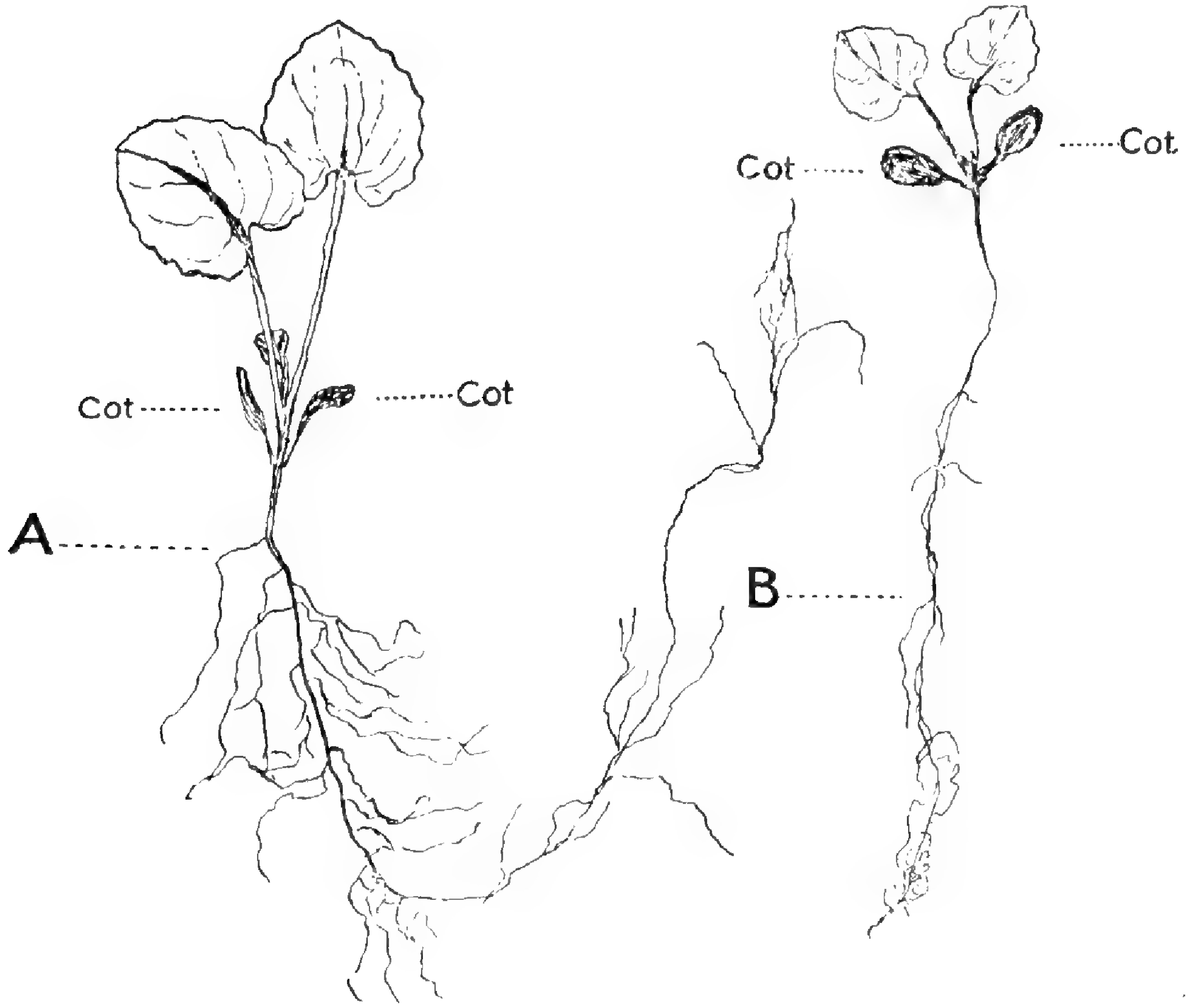
One must remember that, in this country, *Helleborus fœtidus*, whose home is in Southern and Western Europe, is at the extreme of its northern and western distribution, and it is probable that an observer at its head-quarters would find differences in the environment which would throw the needful light upon the problem that the seed-mass still presents. It is conceivable, though perhaps not very probable, that on the continent, where the Roman snail, *Helix pomatia*, is common, or in our southern and midland counties, where it is plentiful, this mollusc, with its larger body, might be a more efficient dispersal agent than our smaller garden-snail, *Helix aspersa*, which, during two nights, cannot have accounted for more than 8 seeds out of 209, or about 4 per cent. ; probably it was only 5 or less, or perhaps none at all, and that under circumstances which one cannot consider unfavourable.

It is impossible to escape the conviction that the mass is an adaptation to some still unknown agent or agents, other than ants—perhaps to some species of bird, or possibly to some mammal or mammals that collect and store food ; and it is much to be desired that some competent naturalist may have, and may avail himself of, an opportunity of observing the dispersal of this plant where it is at home, in the sense of being fruitful and multiplying in a truly wild state. For preference, one would choose its headquarters in South-west Europe ; and until this is done, the meaning of the mass must doubtless remain a mystery.

Meanwhile, one can feel but scant satisfaction with such meagre and unconvincing results—sorry ones, indeed, for the future of *Helleborus fœtidus* in this country, especially in view of its many difficulties, and with all due allowance for rain-runnels and other well-known means of occasional help in dispersal. Probably the soundest conclusion one can draw is the wholesome and chastening one, that one should study the life-history of any given species at or near its head-quarters and in a wild state, instead of in a more or less artificial environment, on the confines of its territory.

Nevertheless, a certain interest attaches to an investigation of this sort, in that it reveals the difficulties and the fearful odds against which an organism has to struggle when at the end of its distributional tether ; if it be true that this plant is so handicapped as it appears to be in such vital matters as its

Helleborus fœtidus, Linn.



T. A. D. phot. & del.

Viola odorata, Linn.

pollination and its seed-dispersal, and if, in addition to this, I am right in thinking that the majority of the seeds do not ripen properly, while the seedlings are much more than decimated by snails, then it is not surprising that *Helleborus fœtidus* is, and is likely to remain, one of our most unfamiliar wild plants.

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EXPLANATION OF PLATE 36.

Helleborus fœtidus, Linn.

Fig. 1. Seed-mass.

2., 3., 4. } The same, showing the connecting strip.

5., 6. } The same, undergoing seed-disintegration.

Seedlings of *Viola odorata*, Linn.

A. Caruncle removed before sowing.

B. Caruncle not removed.

Plants collected in Sikkim, including the Kalimpong District, April 8th to May 9th, 1913. By C. C. Lacaita, F.L.S.

[Read 16th March, 1916.]

The publication of a list of a scanty collection from a district so well known as Darjiling and southern Sikkim is only justified by the fact that Gamble's list deals with the trees, shrubs, and large climbers of the Darjiling district alone; C. B. Clarke's excursion to Tonglo (Journ. Linn. Soc., Bot. xv. (1876) 116–159) was made at a different season, so was Gamble's, and he purposely does not speak of the flora of the forest region, whilst Smith and Cave's lists relate to northern Sikkim.

I reached Darjiling on the 6th of April, 1913; next morning the whole snow range shone gloriously clear, but it was the only complete view of it that I had during the whole of my visit to Sikkim, though many subsequent partial glimpses were far more beautiful, especially from Pemiongchi.

Itinerary.

April 8th. Down to Takvar tea-garden, about 2500′ below Darjiling, through rather open middle forest.

April 9th. Down to Manjhitar bridge on the Great Ranjit river, passing Lebong and the Badantam tea-gardens.

April 11th. From Darjiling by the "Calcutta" road to Senchal and Tiger Hill.

April 13th. To Gumpahar forest beyond Ghoom village.

April 15th. By rail to Kurseong and thence down the old road to Pankabari and back. This is the road by which Hooker first came up to Darjiling, and I fancy some of my specimens must have been plucked from the same trees from which his were taken.

April 19th. By Jore bungalow and Lopchu to Pashok, where I spent two most pleasant evenings with Mr. Lister, the most delightful of companions, intimate with all that lives and grows in the forest.

April 20th. In the forest below Pashok.

April 21st. From Pashok by Tista Bridge to Kalimpong in British Bhotan. Here I joined the party of H.E. the Governor of Bengal, and my movements for the next ten days were governed by his. The Kalimpong side of the Tista was suffering from drought, and botanical results were consequently poor, except on

April 23rd, when I scrambled down to the glen near the junction of two streams in the valley S.E. of Kalimpong, where there is a very varied flora.

April 24th. From Kalimpong to Rhikisum (6400′); the road very dusty and botanically barren till the vicinity of Algarah, where the track to Rhikisum

bungalow branches off to the right from the main Kalimpong-Pedong road.

April 25th. From Rhikisum to Khampung Hill (c. 7800′) on the road to Labah, and back; upper forest with many Aroids.

April 26th. From Rhikisum by Pedong (4760′) to Ari (4800′), crossing the glen of the Rishi Chu, where more time would have enriched my collection, but at that point the frontier of Native Sikkim is crossed, and the arrival of dignitaries with bands and a most picturesque Lepcha guard to welcome H.E. and escort him on his further journey rather distracted my attention from the plants.

April 27th. From Ari via Rhenok (3000′) to Pakhyong (4600′), crossing the Rora Thang.

April 28th. From Pakhyong to Gangtok, crossing the Ronko Chu and the Roro Chu. In a fern-gully below Pakhyong I had my first encounter with leeches. We had not been five minutes among the ferns when there was a cry of "Jonk" (leeches). I took over 40 off my right leg alone; they had almost instantaneously found their way under my socks, in spite of boots and leggings. Several were already inside my hat. Thereafter I was more circumspect when in the leech region.

April 29th. Spent at Gangtok.

April 30th. From Gangtok across the Rahni stream to Song (c. 6000′), stopping on the way to visit the Ramtek Gompa, and passing Murtam. We had hardly reached Song about 3 P.M. when a thunderstorm broke, which seemed to be more violent round Gangtok on the opposite side of the valley. Next day we heard that five men standing together in the bazar at Gangtok had been struck dead.

May 1st. From Song back across the Tista to Temi. Here I was joined by my son for the rest of the tour, and next morning he and I separated from the Governor's party.

May 2nd. From Temi through Demthang forest to Keuzing (c. 5800′), whence there is a glorious view up the upper valley of the Great Ranjit, with Pemiongchi and another monastery crowning two steep hills in the foreground and the great snows beyond.

May 3rd. From Keuzing across the Great Ranjit to Pemiongchi (6900′).

May 4th. Along the ridge from Pemiongchi to Sangachelling (7040′), and thence slanting down to Dentam (4500′) in the valley of the Kulhait Chu.

May 5th. From Dentam a continual ascent by the Mongthang plateau and the glen of the Kulhait Chu to Chiabanjan (10,320′) on the Nepal frontier ridge, and thence southwards along the ridge, crossing the highest point of Singalela (12,130′) to the bungalow on the summit of Phalut (11,820′). Here our fine weather luck deserted us. The next three days were spent in continual mist from which we only got free at Tonglo.

May 6th. Stayed at Phalut, vainly hoping for a view.

May 7th. On along the ridge from Phalut by Subarkum to Sandakphu (11,800′).

May 8th. Sandakphu to Tonglo (10,074′), passing Kalapokri. In the afternoon

I followed the eastern spur of Tonglo, along which runs the track to Pulbazar, and there found several species which I did not notice elsewhere, among them the beautiful *Symplocos dryophila* and *Pyrus Hedlundi*.

May 9th. Tonglo to Darjiling by Manepanjan, Chiman, Sukia, and Jorepokri (7400′). From Manepanjan a forest-ridge is followed of the same character as Gumpahar, of which it is a western prolongation.

The forests of Sikkim have been so often and so well described that I will only say that, with the exception of the Rhododendron region, they struck me as flowerless at all levels at the season when I visited them. The individual flowering trees, shrubs, and plants are scattered and do not form a mass of any colour. A group of *Bauhinia variegata* near Badantam and occasional patches of *Melastoma malabathricum* alone made any great colour impression on my eye. Above the forest-level the flowers must be brilliant later in the year, but when I was there, except a few groups of *Anemone obtusifolia* and some Primulas here and there, nothing but Rhododendrons made any show.

The foliage, especially of the upper forest, is monotonous, almost as much so as in the *Eucalyptus* bush of Australia, the texture and colour of the leaves of trees of quite unrelated genera being curiously similar, due no doubt to parallel adaptation to the climatic conditions.

Perhaps I did not properly appreciate the profusion of orchids, owing to their having been ravaged everywhere near the Governor's route to decorate the flowery arbours erected for the wayside repose of H.E. and for his refreshment with Marwa beer, a taste for which beverage is very quickly acquired in the hot valleys.

The great marvel of the upper forests are the aroids, particularly *Arisæma*; they are so plentiful and of so many species, one more wonderful than another. Perhaps *A. Griffithii* is the most extraordinary. There is a field for glory for any young naturalist who could devote sufficient time and sufficient brains to the study of their life-history, their method of fertilization and the insects concerned in it. What is the function of those astounding filiform appendages which lie along the ground? I never found any insects in the spathes that I opened. Lord Carmichael, whose knowledge of entomology is very exceptional, suggested that these plants may be frequented by small nocturnal spiders guided by these appendages when they encounter them in their peregrinations. They certainly seem to be arranged for creatures whose movements are directed by some sense of touch and not by sight or smell.

This list contains a far greater number of genera and of orders than would be found in the same number of specimens collected in the richest districts of the Mediterranean flora. But this superiority does not extend to species.

Indeed I was surprised to find how relatively easily the species could be determined in most cases when once the plant had been assigned to its proper genus.

A great desideratum for the beginner in Indian botany, whether settling down to work in the east or only a temporary visitor, is a general key to the Indian genera, on the lines of the excellent key at the beginning of Prain's 'Bengal Plants.' Like that it should be a double key, one on the Linnean system and one on more natural principles. The object of a key is not to instruct the student in the scientific relationships of species, but to provide him with the easiest possible short cut to correct determination. The characters required for a Linnean key are generally present in any specimens collected. Those necessary to a "natural" key often imply examination of a plant at different seasons.

The system of the Lepcha collectors for preparing exsiccata is not altogether satisfactory. The bamboo frames they use, often much broken, do not allow of sufficient pressure being applied, for want of which many specimens of trees and shrubs are apt to shed their leaves and most are unnecessarily shrivelled.

It was not likely that I should find new species in such well-known localities, the only approach to an exception being a *Rhododendron* intermediate between *R. Hodgsoni* and *R. Falconeri*; though nearer to the latter it bears flowers the colour of *Hodgsoni*. It is too plentiful between Sandakphu and Chiabanjan to be a hybrid in the ordinary sense. I have named it *R. decipiens*. Subsequent observers on the spot will be able to ascertain its true place.

I have also described and named as *Fragaria rubiginosa* a dwarf strawberry which I consider to be quite wrongly treated as a form of the European *F. vesca*. There is nothing like it in Europe; it is also very different from the other white-flowered Sikkim strawberry, *F. nubicola*.

The following species I believe to be new for Sikkim or at any rate unrecorded for the district, although specimens may be lurking in the Calcutta herbarium or elsewhere :—

RANUNCULUS REPENS, *Linn.* Introduced.

IBERIDELLA ANDERSONI, *Hook. fil.*; my specimens are superficially very unlike those collected by Duthie in Kumaon, but match the type-specimen from Anderson at Kew.

GENTIANA SQUARROSA, *Ledeb.*

MELISSA OFFICINALIS, *Linn.*

CEROPTERIS (§ GYMNOGRAMME) CALOMELANOS, *Underw.*

Dr. A. Brand, from examination of a specimen I sent him, has transferred *Trichodesma calycosum*, Coll. & Hemsl. to a new genus *Lacaitæa*; *L. calycosa* (Coll. & Hemsl.) Brand.

The following trees and shrubs are not in Gamble's list, but those marked * were collected outside the district covered by that list :—

Berberis Wallichiana; *Skimmia melanocarpa* and *Skimmia Wallichii* (probably lumped together in the list as *S. Laureola*) ; *Acer pectinatum*, Wall. (also lumped ?); *Erythrina stricta* (perhaps planted) ; *Cassia lævigata* (ditto) ; *Pyrus Hedlundi* (lumped with *P. lanata*, D. Don ?) ; **Vitis Hookeri* ; *Jasminum undulatum* ; *Vallaris Heynei* ; *Gaultheria pyrolæfolia* ; *Bassia latifolia* ; *Rhododendron campanulatum* ; *Mæsa argentea* ; *Glochidion khasicum*, of which, curiously enough, there is a specimen at Kew collected by Mr. Gamble at the same spot as my own and labelled by him *G. khasicum* ; **Euonymus scandens* ; **Gymnosporia rufa* ; **Vitis lanata* var. *glabra* ; **Sabia campanulata* ; **Spondias axillaris* ; **Randia tetrasperma* ; *Symplocos pyrifolia* (but this is given in the first edition of the list) ; *Machilus Clarkeana* (perhaps lumped with *M. Gammieana*).

I have thought to suit the convenience of Indian botanists by adopting, with very few exceptions, the sequence and nomenclature of the 'Flora of British India' for Phanerogamæ. For the ferns I have, for the same reason, followed Beddome's 'Handbook to the Ferns of British India,' only in some instances preferring Clarke's 'Review of the Ferns of Northern India,' or adopting C. Christensen's name when Beddome's or Clarke's is obviously untenable. Any other course would have involved more time and study than the compilation of such a list can justify.

Finally, I must express my thanks to the botanists who have so kindly helped me in the determination of my plants. First and foremost to Mr. Cave, of the Loyd Botanic Garden at Darjiling, who provided an admirable Lepcha collector always active and good-tempered, and helped me to find my way among so many genera that were strange. Then to the members of the staff of the Herbarium at Kew; nearly all of them, with their never failing courtesy, have helped me with one species or other. Also to Major Gage and Mr. C. C. Calder, and particularly to Mr. Gamble, who has looked over the Laurineæ, the Skimmias and some others. Dr. Brand has kindly revised the *Symplocos* and Dr. W. Becker has named the *Violæ*.

PHANEROGAMÆ.

RANUNCULACEÆ.

ANEMONE OBTUSILOBA, *D. Don*. Glabrescent, flower white with leaden-blue blush beneath. Phalut in sward, c. 11,800′, 5. v. (16071).

—— —— Very hairy, flower blue-purple. Ibidem (16070).

RANUNCULUS DIFFUSUS, *DC*. Lebong, moist woods, c. 6000′, 9. iv. (16069); forest above Rhikisum, c. 7500′, 25. iv. (16068).

—— FLACCIDUS, *Hook. fil. & Thoms*. Chiabanjan in the sward, c. 10,350′, 5. v. (16186).

RANUNCULUS REPENS, *Linn.* Jorepokri Dak Bungalow, in sunny sward, c. 7250′, 9.v. (17626). Certainly introduced; I saw it nowhere else, but the Kew Herbarium has it from near the barracks at Jalapahar.

ISOPYRUM ADIANTIFOLIUM, *Hook. fil. & Thoms.* North slope of Tonglo, in dank shade, c. 9000′, 8.v. (15718); moist rocks between Sukia and Tonglo, c. 8500′, 9.v. (15719).

MAGNOLIACEÆ.

MAGNOLIA CAMPBELLII, *Hook. fil. & Thoms.* Flower varies from very dark pink to almost white. Senchal, c. 8500′, 11.iv. (15859, 15860).

MICHELIA EXCELSA, *Blume.* Gumpahar, c. 7000′, 13.iv. (15857, 15858).

SCHIZANDRA GRANDIFLORA, *Hook. fil. & Thoms.* Near Sukia, c. 7500′, 9.v. (16179).

ANONACEÆ.

MILIUSA ROXBURGHIANA, *Hook. fil. & Thoms.* Glen S.E. of Kalimpong, c. 1900′, 23.iv. (16095).

MENISPERMACEÆ.

CISSAMPELOS PAREIRA, *Linn.* Pankabari, c. 1600′, 15.iv. (15835).

BERBERIDEÆ.

HOLLBOELLIA LATIFOLIA, *Wall.* Above Rhikisum, c. 7500′, 25.iv. (15384, 15385); above Keuzing, c. 6600′, 2.v. (15386); East spur of Tonglo, c. 9250′, 8.v. (15387).

BERBERIS INSIGNIS, *Hook. fil. & Thoms.* Below Chiabanjan, c. 9000′, 5.v. (15388, 15389).

—— NEPALENSIS, *Spreng.* Fruit; between Darjiling and Jalapahar, c. 7200′, 13.iv. (15390).

—— WALLICHIANA, *DC.* Above Kalapokri between Tonglo and Sandakphu, c. 10,000′ 8.v. (15383).

PAPAVERACEÆ.

MECONOPSIS PANICULATA, *Prain.* Leaves only; copious on Singalela, c. 12,000′, 5.v. (16178).

CRUCIFERÆ.

DRABA GRACILLIMA, *Hook. fil. & Thoms.* Flower yellow. Phalut in the sward, c. 11,800′, 6.v. (16177).

CAPSELLA BURSA-PASTORIS, *Moench.* A field weed (15455).

IBERIDELLA ANDERSONI, *Hook. fil. & Thoms.* Flower blush-white to pale lilac, drying pink. Between Phalut and Subarkum in shaly sward, c. 11,500′, 7.v. (16278).

CAPPARIDEÆ.

CAPPARIS MULTIFLORA, *Hook. fil. & Thoms.* Flower white; near the Rahni below Gangtok, c. 2200′, 30.iv. (16093, 16094).

—— OLACIFOLIA, *Hook. fil. & Thoms.* Below Kurseong, c. 3800′, 15.iv. (16175, 16176).

CRATÆVA RELIGIOSA, *Forst.* (Naturalised ?) above Pankabari, c. 2500′, 15.iv. (15465, 15466).

BIXINEÆ.

GYNOCARDIA ODORATA, *R. Br.* In bud; near the Great Ranjit below Badantam, c. 1250′, 9.iv. (16147).

VIOLACEÆ (determined by Dr. W. BECKER).

VIOLA HOOKERI, *T. Thoms.* South shoulder of Tonglo, c. 8500′–9000′, 9.v. (14890, 14892).

—— GLAUCESCENS, *Oudem.* Forest above Rhikisum, c. 7500′, 25.iv. (14891).

—— THOMSONI, *Oudem.* Darjiling, below Birch Hill, c. 6500′, 8.iv. (14885, 14886, 14887): and above Rhikisum, c. 6900′, 25.iv. (14889).

—— SERPENS, *Wall.* Gangtok, c. 6500′, 30.iv. (14888).

PITTOSPOREÆ.

PITTOSPORUM FLORIBUNDUM, *Wight & Arn.* Rhikisum, c. 6400′, 24.iv. (15825, 15826).

CARYOPHYLLACEÆ.

STELLARIA MEDIA, *Cyr.*, var. Stamens 10, petals equalling sepals; below Darjiling, c. 6500′, 8.iv. (16170).

POLYCARPEÆ.

DRYMARIA CORDATA, *Willd.* Form with most leaves ovate and others only slightly cordate; a herb, not a shrub as stated in Fl. Brit. Ind. River-bank at Tista Bridge, c. 660′, 21.iv. (14189).

PORTULACEÆ.

PORTULACA OLERACEA, *Linn.* Sands of river at Tista Bridge.

HYPERICINEÆ.

HYPERICUM HOOKERIANUM, *Wight & Arn.*, var. LESCHENAULTII, *Choisy* (pro spec.). In fruit; Tonglo, c. 9000′, 9.v. (16172).

—— JAPONICUM, *Thunb.* River-bank at Tista Bridge, c. 660′, 21.iv. (15471).

—— PATULUM, *Thunb.* Fruit; above Manepanjan, c. 7800′, 9.v. (16171).

GUTTIFERÆ.

GARCINIA CORVA, *Roxb.* Roro Chu, between Pakhyong and Gangtok, c. 2000′, 28.iv. (16067).

TERNSTRŒMIACEÆ.

EURYA JAPONICA, *Thunb.* Keuzing, c. 6000′, 2.v. (15770).

—— SYMPLOCINA, *Blume.* Mongthang above Dentam, c. 5500′, 5.v. (15771, 15772).

SAURAUJA FASCICULATA, *Wall.* Flower white. Between Kurseong and Pankabari, c. 3000′, 15.iv. (16174).

SAURAUJA PUNDUANA, *Wall.* Flower pink, fading to blush-white. Rora Thong between Rhenok and Pakhyong, c. 2000′, and above Pakhyong, c. 4800′, 27.iv. (15775, 15776, 16173).

STACHYURUS HIMALAICUS, *Hook. fil. & Thoms.* Tonglo, c. 9000′, 9.v. (15769).

SCHIMA WALLICHII, *Choisy.* Young leaves; Lebong, c. 4500′, 9.iv. (15773). Buds and fruit; Kalimpong, c. 4000′, 23.iv. (15774).

CAMELLIA DRUPIFERA, *Lour.* Fruit; below Pemiongchi, c. 5000′, 3.v. (15400).

DIPTEROCARPEÆ.

SHOREA ROBUSTA, *Gaertn.* Below Pashok, c. 2500′, 20.iv. (15451, 15452).

MALVACEÆ.

HIBISCUS PUNGENS, *Roxb.* Flower yellow with chocolate base; Manjhitar Bridge, c. 1250′, 9.iv. (16148, 16149).

TILIACEÆ.

GREWIA VESTITA, *Wall.* Near the Tista below Temi, c. 900′, 1.v. (16276).

ELÆOCARPUS ROBUSTUS, *Roxb.* Flowers white; between Roro Chu and Gangtok, c. 2500′, 28.iv. (15768).

GERANIACEÆ.

GERANIUM NEPALENSE, *Sweet.* Below Darjiling, c. 6000′, 8.iv. (15474); Gumpahar, c. 7000′, 13.iv. (15473); below Keuzing, c. 5500′, 3.v. (15472).

OXALIS CORNICULATA, *Linn.* Below Darjiling, c. 6000′, 8.iv. (15478).

IMPATIENS STENANTHA, *Hook. fil.* Flowers clear yellow; below Pakhyong, c. 4000′, 28.iv. (15475, 15476, 15477).

BURSERACEÆ.

GARUGA PINNATA, *Roxb.* Between Tista Bridge and Kalimpong, c. 2000′, 21.iv. (16166).

RUTACEÆ.

ZANTHOXYLUM OXYPHYLLUM, *Edgw.* Darjiling, by the Auckland road, c. 7000′, 14.iv. (16099); Sangachelling, c. 6800′, 4.v. (16100).

SKIMMIA ARBORESCENS, *T. And.*, MS. in Herb. Kew. Darjiling by the "Calcutta" road, c. 7200′, 11.iv. (15720, 15721).

—— WALLICHII, *Hook. fil. & Thoms.*, MS. in Herb. Kew. Kalapokri between Sandakphu and Tonglo, c. 10,000′, 8.v. (16090).

[Descriptions of these two species will be found on pages 491–2.]

Both these Skimmias were determined by Mr. Gamble and compared by me with Hooker's specimens in Herb. Kew.

CITRUS MEDICA, *Linn.* An escape? near Rhenok, c. 3000′, 27.iv. (16101).

MELIACEÆ.

MELIA AZEDARACH, *Linn.* Planted? Tista Bazar, c. 750′, 21.iv. (15836).

CEDRELA TOONA, *Roxb.* Below Pashok, c. 2500′, 20.iv. (15837, 15838).

ILICINEÆ.

Ilex dipyrena, *Wall.* In fruit; Senchal, c. 8500′, 11. iv. (16108).

—— insignis, *Hook. fil.* In fruit, leaves unarmed; between Jore bungalow and Lopchu, c. 6500′, 19. iv. (16109, 16111); leaves spinose, Gumpahar, c. 7000′, 13. iv. (16107).

—— sikkimensis, *King.* In flower; Chiabanjan, c. 10,000′, 5. v. (16110).

CELASTRINEÆ.

Euonymus theæfolius, *Wall.* Gumpahar, c. 7000′, 13. iv. (16106).

—— scandens, *R. Grah.* (*E. echinatus*, Hook. fil. & Lawson, p. parte, non Wall.; see Sprague in Kew Bull. 1908, p. 33). Sangchelling, c. 7000′, 4. v. (16104, 16105).

Gymnosporia rufa, *Wall.* Between Ramtek Gompa and Murtam, c. 6000′, 30. iv. (16102, 16103).

Celastrus stylosa, *Wall.* Below Pemiongchi, c. 5000′, 3. v. (15464).

AMPELIDEÆ.

Vitis Hookeri, *Lawson* (compared with type at Kew). Glen S.E. of Kalimpong, c. 1800′, 23. iv. (16277).

—— lanata, *Roxb.*, var. glabra, *Lawson.* Quite glabrous, in berry; near Keuzing, c. 6000′, 2. v. (16184).

SAPINDACEÆ.

Sapindus attenuatus, *Wall.* Below Badantam, c. 2000′, 9. v. (15762).

ACERACEÆ.

Acer caudatum, *Wall.* Leaves 5-partite; north slope of Tonglo, c. 9000′, 8. v. (15808, 15809).

—— pectinatum, *Wall.* Leaves 3-partite; Tonglo, c. 9500′, 8. v. (16167, 16168, 16169).

—— Hookeri, *Miq.* Darjiling, on the Auckland road, c. 7200′, 14. iv. (15811); between Jore bungalow and Lopchu, c. 7300′, 19. iv. (15810).

—— Thomsoni, *Miq.* Leaves only; below Lebong, c. 5000′, 9. iv. (15807).

STAPHYLACEÆ.

Turpinia nepalensis, *Wall.* Woods between Darjiling and Takvar, c. 5000′, 8. iv. (15761).

SABIACEÆ.

Sabia campanulata, *Wall.* Below Chiabanjan, c. 9500′, 5. v. (16096).

—— leptandra, *Hook. fil. & Thoms.* Jalapaear, c. 7600′, 13. iv. (16098).

—— parviflora, *Wall.* Kalimpong, c. 4500′, 24. iv. (16097).

Meliosma simplicifolia, *Roxb.* Rora Thong between Rhenok and Pakhyong, c. 1900′, 27. iv. (15755).

ANACARDIACEÆ.

Spondias axillaris, *Roxb.* Ronko Chu between Pakhyong and Gangtok, c. 2000′, 28. iv. (16165).

DRIMYCARPUS RACEMOSUS, *Hook. fil.* Between Kurseong and Pankabari, c. 3000′, 15. iv. (15805, 15806).

PAPILIONACEÆ.

PIPTANTHUS NEPALENSIS, *D. Don.* Head of Kulhait Chu, c. 7000′, 5. v. (15503); E. spur of Tonglo, c. 9000′, 8. v. (15502).

PAROCHETUS COMMUNIS, *Buch.-Ham.* (Scarce at this season.) Above Rhikisum, c. 7500′, 25. iv. (15504).

TEPHROSIA CANDIDA, *DC.* In fruit; below Pashok, c. 2800′, 20. iv. (15505).

MILLETIA PACHYCARPA, *Benth.* Flower pink; Tista banks below Temi, c. 900′, 1. v. (16285).

SHUTERIA VESTITA, *Wight & Arn.* Fruit; below Pashok, c. 2800′, 20. iv. (15505).

ERYTHRINA STRICTA, *Roxb.* Planted or escaped? Hedges between Lebong and Badantam, c. 4000′, 9. iv. (15553).

MUCUNA MACROCARPA, *Wall.* Wings dark purple, standard and keel whitish green. Below Kurseong, c. 4000′, 15. iv. (16158, 16159, 16160).

—— —— Form with the whole flower greenish. Rhikisum, c. 6800′, 29. iv. (16156, 16157).

FLEMINGIA STRICTA, *Roxb.* Banks of the Great Ranjit, below Badantam, c. 1250′, 9. iv. (15500).

DALBERGIA STIPULACEA, *Roxb.* Above Pankabari, c. 1600′, 15. iv. (16286, 16287).

—— TAMARINDIFOLIA, *Roxb.* Banks of Great Ranjit between Keuzing and Pemiongchi, c. 2500′, 3. v. (15501).

CÆSALPINEÆ.

CASSIA LÆVIGATA, *Willd.* In fruit; planted? Hedges between Lebong and Badantam, c. 4000′, 9. iv. (16162).

BAUHINIA VAHLII, *Wight & Arn.* In scrub S.E. of Kalimpong, c. 2500′, 23. iv. (15561, 15562).

—— VARIEGATA, *Linn.* Below Badantam, c. 2000′, 9. iv. (16163, 16164).

MIMOSEÆ.

ENTADA SCANDENS, *Benth.* Dentam, in the valley, c. 4400′, 4. v. (15509, 15510).

ACACIA PENNATA, *Willd.* Rocky bank of stream S.E. of Kalimpong, c. 1900′, 23. iv. (15511).

ALBIZZIA LEBBEK, *Benth.* Above Pankabari, c. 1700′, 15. iv. (15512).

—— PROCERA, *Benth.* Rocky bank of stream S.E. of Kalimpong, c. 1900′, 23. iv. (15513, 15514).

—— STIPULATA, *Boiv.* Below Pashok, c. 2500′, 20. iv. (15515), and Rora Thong between Rhenok and Pakhyong, c. 2000′, 27. iv. (15516).

PITHECOLOBIUM BIGEMINUM, *Benth.* Between Roro Chu and Gangtok, c. 3000′, 28. iv. (15507, 15508).

ROSACEÆ.

PRUNUS NEPAULENSIS, *Steud.* (*Cerasus napaulensis*, Ser.). Jore bungalow, c. 7500′, 19. iv. (15734, 15735).

Prunus rufa, *Wall.* A few double flowers mixed with the rest. N. slope of Tonglo, c. 9500′, 8. v. (15733).

Rubus lasiocarpus, *Sm.* Soshing Gompa above Keuzing, c. 6000′, 2. v. (15725, 15726).

—— **lineatus**, *Reinw.* Leaves only; Darjiling, by the Auckland road, c. 7200′, 14. iv. (15728); Senchal, c. 8500′, 11. iv. (15727).

—— **rosæfolius**, *Sm.* Flower; between Darjiling and Takvar, c. 5000′, 8. iv. (15722). Fruit; Rhikisum, c. 6400′, 24. iv. (15723, 15724).

Fragaria indica, *Andr.* Gumpahar, sunny banks, c. 7000′, 13. iv. (16091, 16092).

The two following Fragarias are regarded by Hooker in Fl. Brit. Ind. as varieties of *F. vesca*, Linn. There is no need to discuss here what is the best arrangement of the strawberries allied to *F. vesca*, and whether they should finally be treated as species or varieties. What I am sure of is that these two Sikkim forms are so distinct from each other, and from any European form, that they are just as well entitled to rank as species as are the European *Fragaria collina* and *F. elatior*. I have therefore unhesitatingly given a specific name to the plant which has not hitherto possessed one.

Fragaria nubicola, *Lindl.* Woodland glades in glen of Kulhait Chu, c. 8000′, 5. v. (15426); Tonglo, in woodland, c. 9250′, 8. v. (15424, 15425).

—— **rubiginosa**, *mihi* = *F. vesca*, var. *collina*, Hook. fil., saltem quoad pl. Sikkimensem, sed minime *F. collina*, Ehrh.

Nana, caule basi crasso quasi sublignoso.

Caules, pedunculi et petioli omnes patenter villosissimi, pilis in sicco saltem rubiginosis, pedunculi diametro duplo triploque longioribus.

Folia petiolo usque ad 4 cm. longo suffulta; foliolis 6–8 nerviis, subrotundo-rhomboideis, mediano subsessili 20–25 mm. longo 15–18 mm. lato; basi cuneata integra, cæterum profunde dentato-serratis, dentibus utrinque 5–7; supra glabris lucentibus, inter nervos propter venulas impressas crebre rugosis; subtus præcipue ad nervos laxe pilosis, pilis substrigosis; serius vero, nervis exceptis, ibi glabrescentibus.

Calyx extus sparse sed patenter hirsutus, laciniis apice sæpissime trifidis, ibique rubro notatis et denso pilorum fasciculo terminatis. Petala parva, alba, basi rubro punctata, calycem paululum excedentia. Fructus usque ad basin carpellis obsitus, calycibus ut videtur adpressis, sed fructus perfecte maturos non vidi.

Fragaria nubicola, silvarum saltus prædiligens, quoad exemplaria Sikkimensia toto cælo differt caule petiolisque longioribus, et præsertim hirsutia, argentea nec rubiginosa, pilis caulinis et petiolorum patulis, pedunculorum vero adpressis; foliolis oblique ovatis vel ovalibus, 9–10 nerviis, usque ad basin fere dentatis, dentibus utrinque circa 10; supra sparse pilosis et inter nervos planis nec rugosis, subtus adpresse sericeo-pilosis; calyce pilis adpressis sericeo, laciniis augustioribus, plerumque integris, apice nec rubro notatis nec tam conspicue barbatis; flore duplo majore petalis, nisi fallor, immaculatis. Fructus *F. nubicolæ* non vidi.

Open grassy ridges, Senchal, c. 8250′, 11. iv. (15423); below Chiabanjan, c. 9000′, 5. v. (15421); Sandakphu, c. 11,750′, 7. v. (15422).

The rusty colour of the whole plant, especially when dry, contrasts with the silvery appearance of *F. nubicola*, from which it also differs in its preference for open sunny sward, whilst *nubicola* inhabits the glades of the upper forest.

POTENTILLA KLEINIANA, *Wight & Arn.* Near Sukia, c. 7300′, 9. v. (16151).

—— MOONIANA, *Wight.* Between Chiabanjan and Singalela, c. 11500′, 5. v. (16150).

ROSA SERICEA, *Lindl.* Below Sandakphu, c. 10,800′, 8. v. (15736, 15737).

PYRUS FOLIOLOSA, *Wall.* Forma foliis obsolete serratis. Tonglo, shoulder towards Pulbazar, c. 9000′, 8. v. (16155).

—— HEDLUNDI, *mihi.* (*Sorbus Hedlundi*, C. K. Schneider) in Laubholzkunde, i. p. 685 (May 1906). Compared with Schneider's type at Kew; petals white, stamens pink; underside of leaves snowy white with orange nerves. Tonglo, Pulbazar shoulder, c. 9000′, 8. v. (16153, 16154).

COTONEASTER MICROPHYLLA, *Wall.*, var. GLACIALIS, *Baker.* Rocks of Singalela, c. 12,000′, 5. v. (15283).

ERIOBOTRYA PETIOLATA, *Hook. fil.* Gumpahar, c. 7000′, 13. iv. (15729); Rhikisum, c. 6400′, 24. iv. (15730).

CUCURBITACEÆ.

THLADIANTHA CALCARATA, *C. B. Clarke*? Specimen (male only) too poor; woodland below Pakhyong, c. 3000′, 28. iv. (16627).

CRASSULACEÆ.

BRYOPHYLLUM CALYCINUM, *Salisb.* Between Kurseong and Pankabari, c. 3800′, 15. iv. (15446).

COMBRETACEÆ.

TERMINALIA CHEBULA, *Retz.* Flower; Tista valley below Temi, c. 900′, 1. v. (15460).

—— TOMENTOSA, *Beddome.* Fruit; above Pankabari, c. 2000′, 15. iv. (15459).

COMBRETUM DECANDRUM, *Roxb.* Fruit; above Pankabari, c. 2000′, 15. iv. (15461, 15462).

MYRTACEÆ.

EUGENIA JAMBOS, *Linn.* Flower; planted? Rhenok, c. 3000′, 27. iv. (16089).

—— KURZII, *Duthie.* Fruit as large as a small cherry, not pea size as stated in Fl. Brit. Ind. Between Darjiling and Takvar, c. 5000′, 8. iv. (16088).

MELASTOMACEÆ.

OSBECKIA CRINITA, *Benth.* Fruit only; above Temi, c. 6000′, 2. v. (16152).

MELASTOMA MALABATHRICUM, *Linn.* Below Badantam, c. 2000′, 9. iv. (15854); between Pedong and Rishi Chu, c. 2000′, 26. iv. (15855).

Medinilla rubicunda, *Blume*. Between Gangtok and the Rahni, c. 2500′, 30. iv. (15853).

LYTHRACEÆ.

Woodfordia floribunda, *Salisb.* In Sal forest between Badantam and the Great Ranjit, c. 1500′, 9. iv. (15844, 15845).

Duabanga sonneratioides, *Buch.-Ham.* Below Pashok, c. 2500′, 20. iv. (15839, 15840).

SAMYDACEÆ.

Casearia glomerata, *Roxb.* Above Lebong, c. 6000′, 9. iv. (15757); between Pemiongchi and Sangachelling, c. 6900′, 4. v. (15756).

BEGONIACEÆ.

Begonia laciniata, *Roxb.* Near Algarah, c. 6000′, 24. iv. (16083).

—— rubrovenia, *Hook. fil.* Tista valley between Song and Temi, c. 900′, 1. v. (16081).

—— xanthina, *Hook. fil.* Rhikisum, c. 6400′, 24. iv. (16082).

SAXIFRAGACEÆ.

Tiarella polyphylla, *D. Don.* Kulhait Chu, c. 8500′, 5. v. (15754).

Chrysosplenium nepalense, *D. Don.* Rill-sides, Senchal, c. 8000′, 11. iv. (15747); Rhikisum, c. 7500′, 25. iv. (15748).

—— species? Very dwarf; identical with Herb. Watt nos. 5306, 5405, and 5428 of 28 and 29 v. 1881, all from Ritampoo. These are referred to *C. nepalense* by C. B. Clarke in Herb. Kew, but I suspect that they are a different species. Phalut, in open sward, c. 11,800′, 6. v. (16187).

Hydrangea altissima, *Wall.* Kulhait Chu, c. 7500′, 5. v. (15751).

—— robusta, *Hook. fil. & Thoms.* Rhikisum, c. 6400′, 24. iv. (15752).

Dichroa febrifuga, *Lour.* Fruit; Gumpahar, c. 7000′, 13. iv. (15749); above Lopchu, c. 5000′, 19. iv. (15750).

Itea macrophylla, *Wall.* In bud; by the Rahni below Gangtok, c. 2000′, 30. iv. (16575).

Ribes glaciale, *Wall.* Above Chiabanjan, c. 10,500′, 5. v. (15753).

UMBELLIFERÆ.

Œnanthe Thomsoni, *C. B. Clarke.* Flat haugh at Singtam between Pakhyong and Gangtok, c. 1500′, 28. iv. (16084).

CORNACEÆ.

Marlea begoniæfolia, *Roxb.* Tista valley below Temi, c. 950′, 1. v. (15457, 15458).

Cornus capitata, *Wall.* Near Manepanjan, c. 7000′, 9. v. (15455, 15456).

Aucuba himalaica, *Hook. fil.* Above Rhikisum, c. 7500′, 25. iv. (15453, 15454).

CAPRIFOLIACEÆ.

Viburnum Colebrookianum, *Wall.* Above Pedong, c. 5000′, 26. iv. (15787).

—— cordifolium, *Wall.* Chiabanjan, c. 10,500′, 5. v. (15786).

VIBURNUM ERUBESCENS, *Wall.*; var. *a*, *Hook. fil.* & *Thoms.* Leaf shiny, flower blush-white. Above Temi, c. 6000′, 2. v. (15783); Mongthang, above Dentam, c. 5500′, 5. v. (15780).

—— ——; var. *b*, *Hook. fil.* & *Thoms.* Leaf large, cordate, not shiny; texture thin; panicle ample, flower white. Above Pakhyong, c. 4800′, 27. iv. (15785); below Pakhyong, c. 4400′, 28. iv. (15784); Keuzing, c. 5600′, 3. v. (15781).

—— ——; var. *d*, *Hook. fil.* & *Thoms.* Leaf narrowly elliptic-ovate, stellately pubescent and with copious ruddy glands beneath; texture thick; upper surface furrowed along nerves; panicle contracted; outer pair of bracts conspicuously broader and longer than the rest; pedicels thick; flower full pink. Demthang forest above Temi, c. 6500′, 2. v. (15782).

—— ——; form with inflorescence of var. *a*, but leaves approaching those of var. *d*. Kulhait Chu, c. 7000′, 5. v. (15788).

LEYCESTERIA FORMOSA, *Wall.* Fruit; above Rhikisum, c. 7500′, 25. iv. (15777, 15778).

PENTAPYXIS STIPULATA, *Hook. fil.* & *Thoms.* Darjiling by "Calcutta" road, c. 7300′, 11. iv. (15779).

ARALIACEÆ.

HEPTAPLEURUM VENULOSUM, *Seem.* Near the Great Ranjit below Badantam, c. 1300′, 9. iv. (15791, 15792).

TREVESIA PALMATA, *Vis.* Below Pashok, c. 2500′, 20. iv. (16085, 16086, 16087).

HETEROPANAX FRAGRANS, *Seem.* Kishing below Pemiongchi, c. 4000′, 3. v. (15789, 15790).

BRASSAIOPSIS HISPIDA, *Seem.* Above Rhikisum, c. 7000′, 25. iv. (15793, 15794, 15795).

RUBIACEÆ.

UNCARIA PILOSA, *Roxb.* Roro Chu between Pakhyong and Gangtok, c. 2000′, 28. iv. (15711).

CINCHONA, hybrid form? Escape from former cultivation at Pashok, c. 3400′, 20. iv. (15716).

LUCULIA GRATISSIMA, *Sweet.* Fruit; Rhikisum, c. 6400′, 24. iv. (15712).

WENDLANDIA CORIACEA, *DC.* Near the Great Ranjit below Badantam, c. 1500′, 9. iv. (15710).

—— TINCTORIA, *DC.*, var. GRANDIS, *Hook. fil.* Below the Pashok Dak Bungalow, c. 1800′, 21. iv. (16080).

OPHIORHIZA FASCICULATA, *D. Don.* Between Roro Chu and Gangtok, c. 2500′, 28. iv. (15715); near the Rahni below Gangtok, c. 2000′, 30. iv. (15714).

MUSSÆNDA GLABRA, *Wall.* Between Pedong and Rishi Chu, c. 2000′, 26. iv. (16076, 16077).

COFFEA BENGALENSIS, *Roxb.* Below Badantam, c. 2000′, 9. iv. (15717).

MORINDA ANGUSTIFOLIA, *Roxb.* Below Pashok, c. 2500′, 20. iv. (16074, 16075).

CHASALIA CURVIFLORA, *Thwaites.* Glen S.E. of Kalimpong, c. 1800′, 23. iv. (16078, 16079).

Randia fasciculata, *DC.* In scrub S.E. of Kalimpong, c. 2500′, 23. iv. (15713).

—— tetrasperma, *Roxb.* Rocks between Ramtek Gompa and Murtam, c. 6000′, 30. iv. (16073); rocks by Soshing Gompa near Keuzing, c. 6000′, 2. v. (16072).

Hyptianthera stricta, *Wight & Arn.* Pemiongchi, c. 6900′, 3. v. (15709).

COMPOSITÆ.

Vernonia cinerea, *Less.*? A large-flowered form; nothing quite similar in Herb. Kew. A weed in tea-garden; Badantam, c. 2800′, 9. iv. (16043).

—— talaumifolia, *Hook. fil. & Thoms.* By the Great Ranjit below Badantam, c. 1250′, 9. iv. (16058, 16059).

Ageratum conyzoides, *Linn.* Between Kurseong and Pankabari, c. 3000′, 15. iv. (15675).

Conyza stricta, *Willd.* Badantam; a tea-garden weed; c. 2800′, 9. iv. (16061).

Blumea balsamifera, *DC.* Below Pashok Dak Bungalow, c. 1800′, 21. iv. (16063, 16064).

—— chinensis, *DC.* Lopchu, c. 4500′, 19. iv. (16056).

—— cinerascens, *DC.* Great Ranjit below Badantam, c. 1250′, 9. iv. (16057). The quite glabrous receptacle brings this nearer to *B. lacera*, DC. than to *B. runcinata*, DC., to which Clarke refers specimens "ex eodem loco."

—— procera, *DC.* Woods between Darjiling and Takvar, c. 6000′, 8. iv. (16062).

—— squarrosa, *C. B. Clarke.* The very hairy receptacle clearly separates this from *B. myriocephala*, DC., with which it is united in Fl. Brit. Ind. Between Badantam and the Great Ranjit, c. 1800′, 9. iv. (16054, 16055).

—— Wightiana, *DC.* Badantam tea-garden, c. 2800′, a weed, 9. iv. (16060).

Gnaphalium multiceps, *Wall.* The reduction of this species to *G. luteoalbum*, Linn. is surely unjustified. Darjiling, c. 7000′, 8. iv. (15672).

—— purpureum, *Linn.* Badantam tea-garden, c. 2800′, a weed, 9. iv. (16066).

Siegesbeckia orientalis, *Linn.* Tista Bridge, c. 750′, 21. iv. (15684).

Tithonia tagetifolia, *Desf.* Fruit; between Kurseong and Pankabari, c. 3800′, 15. iv. (15678).

Spilanthes Acmella, *Linn.*, var. calva, *C. B. Clarke.* Rhenok, c. 3000′, 27. iv. (15683).

Bidens pilosa, *Linn.* Badantam tea-garden, c. 2600′, 9. iv. (15673); between the Tista and Temi, c. 1500′, 1. v. (15670).

Tridax procumbens, *Linn.* Pashok tea-garden, a weed, c. 3000′, 20. iv. (16053).

Gynura nepalensis, *DC.* Below Lebong, c. 5000′, 9. iv. (15669); Pashok tea-garden, c. 2500′, 20. iv. (16183).

Saussurea hypoleuca, *Spreng.*? ex loco, but the specimen is undeterminable. Phalut, in sward, c. 11,800′, 5. v. (16052).

Ainsliæa pteropoda, *DC.* Above Lopchu, c. 5000′, 19. iv. (15679, 15680); above Rhikisum, c. 7100′, 25. iv. (15681, 15682).

Picris Hieracioides, *Linn.* Sangachelling, a weed, c. 7040′, 4. v. (15671).

Taraxacum officinale, *Web.*, forma. Chiabanjan, in sward, c. 10,300′, 5. v. (15668).

Lactuca graciliflora, *DC.* Badantam tea-garden, c. 2800′, 9. iv. (15676).

LOBELIACEÆ.

Pratia begonifolia, *Lindl.* Between Gangtok and the Rahni, c. 2000′ 30. iv. (16185).

—— montana, *Hassk.* Above Rhikisum, c. 7400′, 25. iv. (15846, 15847).

Lobelia affinis, *Wall.* Above Rhikisum in deep shade, c. 6900′, 25. iv. (16182 *a*); Demthang forest above Temi, c. 6500′, 2. v. (16182 *b*).

—— pyramidalis, *Wall.* Between Kurseong and Pankabari, c. 3000′, 15. iv. (15841); between Darjiling and Takvar, c. 5500′, 8. iv. (15842, 15843).

VACCINIACEÆ.

Agapetes saligna, *Hook. fil.* Between Kurseong and Pankabari, c. 3000′, 15. iv. (15700).

Pentapterygium serpens, *Klotzsch.* Darjiling, c. 7000′, 8. iv. (15698, 15699).

Vaccinium Nummularia, *Hook. fil. & Thoms.* Above Kalapokri between Tonglo and Sandakphu, c. 10,000′, 8. v. (15696).

—— retusum, *Hook. fil.* Senchal, c. 8000′, 11. iv. (15695).

—— serratum, *Wight.* Between Darjiling and Takvar, c. 6000′, 8. iv. (15692).

ERICACEÆ.

Gaultheria fragrantissima, *Wall.* In fruit; Darjiling, by the "Calcutta" road, c. 7000′, 11. iv. (15493).

—— nummularioides, *D. Don.* Darjiling, c. 6500′, 8. iv. (15495).

—— pyrolæfolia, *Hook. fil.* Between Phalut and Subarkum, c. 11,500′, 7. v. (15494).

—— trichophylla, *Royle.* Between Phalut and Subarkum, c. 11,500′, 7. v. (15494).

Pieris formosa, *D. Don.* Leaves only; above Kalapokri between Tonglo and Sandakphu, c. 10,000′, 8. v. (16065).

—— ovalifolia, *D. Don.* Flower; Soshing Gompa above Keuzing, c. 6300′, 2. v. (15498). Fruit; between Darjiling and Jalapahar, c. 7200′, 13. iv. (15497).

Enkianthus himalaicus, *Hook. fil. & Thoms.* Tonglo, c. 9500′, 8. v. (15470).

Rhododendron arboreum, *Sm.*, var. Campbelliæ, *Hook. fil.* Flower scarlet, Chiabanjan, c. 10,000′ (15571); carmine, between Singalela and Phalut, c. 11,400′ (15660, 15661); pink, ibidem (15570) (all on 5. v.); pure white, above Kalapokri between Tonglo and Sandakphu, c. 10,000′, 8. v. (15569).

—— campanulatum, *D. Don.*, var. Wallichii, *Hook. fil.* Flower pale lilac, here and there between Chiabanjan and Phalut, 10,000′ to 11,500′, 5. v. (15436, 15439, 16051); flower pure white, scarce, Sandakphu, c. 12,000′, 7. v. (15437, 15438). This species is very abundant near the summit of Sandakphu, almost to the exclusion of other Rhododendrons.

—— barbatum, *Wall.* Between Chiabanjan and Singalela, c. 10,500′, 5. v. (15666).

—— cinnabarinum, *Hook. fil.* Rocky ground between Chiabanjan and Singalela, c. 11,000′, 5. v. (15572, 15573); above Kalapokri between Tonglo and Sandakphu, c. 10,000′, 8. v. (15574).

Rhododendron Dalhousiæ, *Hook. fil.* Jalapahar, c. 7400′, 13. iv. (15667).

—— grande, *Wight.* Senchal, c. 8500′, 11. iv. (15663, 15664, 15665).

—— Falconeri, *Hook. fil.* Chiabanjan, where it is very plentiful, c. 10,300′, 5. v. (15562, 15581, 15582); in fruit, ibidem, coll. Ribu, October 1913 (18442, 18443, 18444).

This form, which seemed to me predominant on the Nepal frontier range from Sandakphu to Chiabanjan, has uniformly cream-coloured flowers, spotted in the throat, from 25 to 35 in the truss, about 4 cm., or less, across and the same in length. Ovary very woolly and filaments hairy. Capsules 3 to 4 cm. long and 15 to 18 mm. in diameter. Leaves averaging 20 by 11 cm., but some 30 by 14 cm. The upper surface copiously and deeply wrinkled; the under surface buried in thick ferruginous tomentum. It seems to prefer the slopes and hollows and to avoid the exposed ridge, where *Hodgsoni* and *Campbelliæ* flourish. I did not notice any *Falconeri* on the summit of Tonglo, where there is a fine group of *Campbelliæ.*

—— Hodgsoni, *Hook. fil.* Between Chiabanjan and Singalela, c. 11,000′, 5. v. (15579, 15580), the bluish pink form usual in cultivation; below the summit of Singalela, c. 11,500′, 5. v. (15576, 15577), splendid imperial purple; much finer than the usual form. The leaves are longer in proportion than those of *Falconeri,* varying in my specimens from 18 by 7 cm. to 40 by 12 cm. The surface smooth above and densely coated with a pale scaly indumentum (as seen without use of the microscope) beneath. The ovary is densely tomentose (not "glandular scarcely pubescent" as stated by Clarke in Fl. Brit. Ind.), but the filaments are glabrous or almost so. The fully developed trusses bear from 25 to 35 flowers. The capsules (judging from Clarke's Jongri specimen) are about 3½ cm. long and only 5 mm. in diameter—quite different in shape from those of *Falconeri.*

—— decipiens, *mihi* (sp. nov.). Arborescens; folia elliptica vel obovato-elliptica, basi aut angustata aut subcordata, circa 20–22 cm. longa, 9–11 cm. lata, supra propter venulas impressas crebre rugosa, sed forsan minus conspicue quam in *R. Falconeri*; juniora subtus tomento ferrugineo detersili (ei *R. Falconeri* simili, sed minus denso) obsita, quo deterso persistit indumentum pallidum, quasi lepidotum, ei *R. Hodgsoni* (sine microscopii usu) non omnino absimile. Petioli, ut in affinibus, circa 3–3½ cm. longi, robusti.

Corymbi terminales, 25–30-flori, pedicellis circa 2 cm. longis, fructiferis vero usque ad 5 cm. productis. Calycis lobi, ut in affinibus, brevissimi.

Corolla purpureo-rosea, ei *R. Hodgsoni* forma et colore similis. Ovarium tomentosum. Filamenta sparse pilosula. Capsulæ 4–5 cm. longæ, 10–13 mm. latæ, ideoque inter eas *R. Hodgsoni* et *R. Falconeri* intermediæ, sed hisce propiores.

Foliis ad *R. Falconeri,* florum colore ad *R. Hodgsoni* accedens, sed capsulis ambiguus, varietas hucusque indescripta *R. Falconeri* floribus purpureo-roseis (non carneis) videretur, nisi capsulis nonnihil discrepuisset. In loco natali nimis copiose provenit ut pro hybrido *R. Falconeri* et *R. Hodgsoni* habeatur.

Between Chiabanjan and Singalela (with purple-pink flower), c. 11,000′, 5. v. (15578); above Kalapokri between Longlo and Sandakphu (pale pink), c. 10,000′, 8. v. (15575); Singalela (in fruit), coll. Ribu, October 1913 (18445, 18446).

When on the spot I assumed this, from its colour and general appearance, to be a variant of *R. Hodgsoni*, among which it grows promiscuously, and the words of Clarke's description of *R. Hodgsoni* in Fl. Brit. Ind. iii. p. 464, "leaves *cinnamoneous* or white-tomentose beneath," seem to suggest this form. But Dr. Stapf has pointed out to me that most of the characters, except the colour of the flower, are nearer to *R. Falconeri*. The shape of the capsule, assuming that the specimens collected by Ribu in the autumn really belong to the species I saw in flower on the same ground in spring, apart from any other differences, makes it quite impossible to assign it to a form of *R. Hodgsoni*.

RHODODENDRON? Form with broadly elliptic leaves, 18 by 12 cm., otherwise resembling those of *R. Falconeri*, but with flowers crimson in bud. Of this I only could find a single tree, not yet in full flower. *Hodgsoni* and *decipiens* were plentiful all round; *Falconeri* also present but scarce. Between Subarkum and Sandakphu, c. 11,000′, 7. v. (16275).

PRIMULACEÆ.

PRIMULA DENTICULATA, *Sm.* Phalut, c. 11,800′, 5. v. (15484, 15485).

—— PETIOLARIS, *Wall.*, var. NANA, *Hook. fil.* Between Chiabanjan and Singalela, c. 11,500′, 5. v. (15428); Subarkum, c. 11,250′, 7. v. (15427).

—— —— var. SCAPIGERA, *Hook. fil.* Below Chiabanjan in woodland, c. 9500′, 5. v. (15431); between Sandakphu and Kalapokri, c. 10,500′, 8. v. (15429, 15430).

—— ROTUNDIFOLIA, *Wall.* (*Cf.* Watt 5375 from Singalela range in Herb. Kew.). In bud only; Sandakphu, under shady rocks, c. 11,500′, 7. v. (16188).

—— MACROPHYLLA, *D. Don* = *purpurea*, Royle (treated as a variety of *P. Stuartii*, Wall. by Watt and by Hook. fil., but of *P. nivalis*, Pall. by Pax, who however expresses doubt of its presence in Sikkim!). Between Subarkum and Sandakphu, c. 11,500′, 7. v. (15482, 15483).

LYSIMACHIA JAVANICA, *Blume.* Tista Valley below Temi, c. 900′, 1. v. (16049).

—— PROLIFERA, *Klatt.* Flower pale pink to blush-white; copious in sward at Chiabanjan, c. 10,300′, 5. v. (16288). By some oversight this is included in Fl. Brit. Ind. among the species with "flowers in elongate terminal racemes."

MYRSINEÆ.

MÆSA ARGENTEA, *Wall.* Not in Gamble's list. Above Manepanjan, c. 7800′, 9. v. (16044, 16045).

—— CHISIA, *D. Don.* Flower; between Darjiling and Takvar, c. 6000′, 8. iv. (15417, 15418); fruit, ibidem, c. 5000′ (15415).

—— INDICA, *Wall.* S.E. of Kalimpong, c. 3000′, 23. iv. (15419).

—— —— With deformed inflorescence; below Pashok, c. 3000′, 20. iv. (15420).

MÆSA MACROPHYLLA, *Wall.* Below Kurseong, c. 3800′, 15. iv. (15413).
—— RUGOSA, *C. B. Clarke.* Above Rhikisum, c. 6700′, 25. iv. (15414).
MYRSINE SEMISERRATA, *Wall.* Gumpahar, c. 7000′, 13. iv. (16046).
ARDISIA MACROCARPA, *Wall.* Fruit; Lopchu, c. 4200′, 19. iv. (15396, 15397).

SAPOTACEÆ.

BASSIA LATIFOLIA, *Roxb.* Between Kurseong and Pankabari, c. 3000′, 15. iv. (16047, 16048).

STYRACEÆ.

STYRAX HOOKERI, *C. B. Clarke.* Rhikisum, 6400′, 25. iv. (15760).
—— SERRULATUM, *Roxb.* Above Pankabari, c. 2500′, 15, iv. (15758, 15759).

SYMPLOCACEÆ.

SYMPLOCOS DRYOPHILA, *C. B. Clarke.* Flower; Tonglo, near Gaeripas, c. 9500′, 8. v. (15403, 15416); and on the Pulbazar spur, c. 9500′, 8. v. (15402). This is much the finest of the Sikkim *Symplocos*; it is a considerable tree, with very conspicuous flower-spikes.
—— GLOMERATA, *King.* In bud; Gumpahar, c. 6800′, 13. iv. (15407); flower, Demthang, c. 6500′, 2. v. (15405, 15406); flower and fruit, between Pemiongchi and Sangachelling, c. 6800′, 4. v. (15404).
—— PYRIFOLIA, *Wall.* Flower, Darjiling by the "Calcutta" road, c. 7000′, 11. iv. (15409); fruit, Pemiongchi, c. 6700′, 3. v. (15410).
—— RAMOSISSIMA, *Wall.*, "forma foliis basi cuneatis," A. Brand in lit. Mongthang, c. 5500′, 5. v. (16625); above Manepanjan, c. 7800′, 9. v. (16774).
—— SUMUNTIA, *Buch.-Ham.* Flower; east of Jore bungalow, c. 7300′, 19. iv. (15408).
—— THEÆFOLIA, *Buch.-Ham.* Fruit; near Manepanjan, c. 7500′, 9. v. (15411, 15412).

(All the *Symplocos* determined by Dr. A. BRAND.)

OLEACEÆ.

JASMINUM DISPERSUM, *Wall.* Lopchu, 4500′, 19. iv. (15828, 15829); Rhikisum, c. 6400′, 24. iv. (15827).
—— UNDULATUM, *Ker.* Fruit; below Badantam, c. 2000′, 9. iv. (16050).
OSMANTHUS SUAVIS, *King.* Tonglo spur towards Pulbazar, c. 9000′, 8. v. (15832, 15833).
LIGUSTRUM CONFUSUM, *Decne.* Between Dentam and Sangachelling, c. 5500′, 4. v. (15830, 15831).

APOCYNACEÆ.

PLUMERIA ACUTIFOLIA, *Poir.* Pankabari (planted ?), c. 15. iv. (15802).
TABERNÆMONTANA CORONARIA, *R. Br.* An escape? above Pankabari, c. 2000′, 15. iv. (15799).
VALLARIS HEYNEI, *Spreng.* Pankabari, c. 1500′, 15. iv. (15800, 15801).
WRIGHTIA TOMENTOSA, *Rœm. & Schult.* Pankabari, c. 1600′, 15. iv. (16038, 16039).

ASCLEPIADEÆ.

ASCLEPIAS CURASSAVICA, *Linn.* A weed; Tista Valley below Temi, c. 900′, 1. v. (15796, 15797).

HOYA GLOBULOSA, *Hook. fil.* Glen S.E. of Kalimpong, c. 1900′, 23. iv. (16041).

—— LANCEOLATA, *Wall.* Between the Roro Chu and Gangtok, c. 3000′, 28. iv. (16040).

GENTIANEÆ.

CRAWFURDIA LUTEO-VIRIDIS, *C. B. Clarke.* Senchal, c. 8500′, 11. iv. (15469).

GENTIANA CAPITATA, *Buch.-Ham.*, var. ANDERSONI, *C. B. Clarke.* In woodland; above Rhikisum, c. 7500′, 25. iv. (16035 *a*); below Chiabanjan, c. 10,000′, 5. v. (16035 *b*).

—— —— var. STROBILIFORMIS, *Hook. fil.* In open sward, Phalut, c. 11,800′, 6. v. (16036 *a*); Sandakphu, c. 11,800′, 7. v. (16036 *b*). The difference of habitat, and more so the utterly different leaf-texture, makes it probable that these varieties should be regarded as different species.

—— QUADRIFARIA, *Blume.* Darjiling, c. 7000′, 8. iv. (15468); above Rhikisum, c. 7500′, 25. iv. (15467).

—— SQUARROSA, *Ledeb.* Between Sandakphu and Subarkum, c. 11,000′, 7. v. (16181).

BORAGINEÆ.

EHRETIA ACUMINATA, *R. Br.* Rishi Chu below Pedong, c. 2800′, 26. iv. (16033).

—— WALLICHIANA, *Hook. fil. & Thoms.* Flower; below Badantam, c. 2500′, 9. iv. (15380); Mongthang above Dentam, c. 6000′, 5. v. (15382); fruit, above Pankabari, c. 3000′, 15. iv. (15381).

TRICHODESMA CALYCOSUM, *Coll. & Hemsl.* In scrub S.E. of Kalimpong, c. 2500′, 23. iv. (16112, 16113). The only specimen at Kew of this species is the type, collected by Collett in the southern Shan States, but in Herb. Calcutta there are the following:—(1) Labdah, Sikkim, 3000′, no. 3575 coll. Ribu & Rhomos. (2) Mungpo, Sikkim, no. 53, coll. G. H. Cave. (3) Sikkim, 1200′, no. 526, coll. Kari. (4) Sikkim Himalaya, coll. G. A. Gammie. (5) Riang, Mungpo, Sikkim, 1500′, coll. Kari. (6) Dumsong, Darjiling, no. 7544, coll. Gamble. (7) S. Shan States, coll. Collett. (8) Ninbu, Upper Burma, coll. Mokim.

CONVOLVULACEÆ.

IPOMÆA VITIFOLIA, *Sweet.* Pashok Dak Bungalow, c. 2000′, 21. iv. (15447, 15448).

CONVOLVULUS ARVENSIS, *Linn.* forma ? ? unlike any European form I have seen. A weed in Pashok tea-garden, c. 3500′, 20. iv. (16034).

PORANA RACEMOSA, *Roxb.* In seed; above Pankabari, c. 3000′, 15. iv. (15449).

SOLANACEÆ.

SOLANUM INDICUM, *Linn.* Escaped; Tista Bridge, c. 700′, 21. iv. (15303); by the Great Ranjit below Pemiongchi, c. 2500′, 3. v. (15394).

—— NIGRUM, *Linn.* Tista Bridge, c. 700′, 21. iv. (16233).

SOLANUM TORVUM, *Sw.* Above Pankabari, c. 3000′, 15. iv. (15392).

—— VERBASCIFOLIUM, *Linn.* Below Pakhyong, c. 4400′, 28. iv. (15395).

PHYSALIS PERUVIANA, *Linn.* Escaped; below Gangtok, c. 4000′, 30. iv. (16234).

MANDRAGORA CAULESCENS, *C. B. Clarke.* Phalut, in sward, c. 11,600′, 6. v. (15393 *a*); Subarkum, c. 11,400′, 7. v. (15393 *b*).

DATURA FASTUOSA, *Linn.* Cultivated flat at Singtam below Gangtok, c. 2000′, 28. iv. (16232).

SCROPHULARINEÆ.

MIMULUS NEPALENSIS, *Benth.* Rillside between Jore bungalow and Lopchu, c. 6500′, 19. iv. (15743).

MAZUS SURCULOSUS, *D. Don.* In sward; Rhikisum, c. 6400′, 24. iv. (15746); near Sangachelling, c. 6000′, 4. v. (15744, 15745).

LINDENBERGIA GRANDIFLORA, *Benth.* Darjiling, c. 7000′, 8. iv. (15740).

—— HOOKERI, *C. B. Clarke.* Between Kurseong and Pankabari, c. 3000′, 15. iv. (15741, 15742).

HEMIPHRAGMA HETEROPHYLLUM, *Wall.* Below Darjiling, c. 6500′, 8. iv. (15738); top of Senchal, c. 8600′, 11. iv. (15739).

GESNERACEÆ.

ÆSCHYNANTHUS GRACILIS, *Parish.* Near the Ronko Chu below Pakhyong, c. 2000′, 28. iv. (16042).

ACANTHACEÆ.

ERANTHEMUM INDICUM, *C. B. Clarke.* Woods between Darjiling and Takvar, c. 6000′, 8. iv. (15815).

DÆDALACANTHUS NERVOSUS, *T. Anderson.* By the Great Ranjit below Badantam, c. 1250′, 9. iv. (15812); between Pashok and the Tista, c. 1200′, 21. iv. (15689).

LEPIDAGATHIS HYALINA, *Nees.* Below Badantam, c. 2000′, 9. iv. (16032).

—— SEMIHERBACEA, *Nees.* Regarded as a mere narrow-leaved form of *L. hyalina* in Fl. Brit. Ind., but it should be further studied on the spot. By the Great Ranjit below Badantam, c. 1250′, 9. iv. (16031).

PHLOGACANTHUS THYRSIFLORUS, *Nees.* Below Badantam, c. 2000′, 9. iv. (15816).

ADHATODA VASICA, *Nees.* Introduced in a hedge at Kurseong, c. 4500′, 15. iv. (15813, 15814).

PERISTROPHE SPECIOSA, *Nees.* Between Darjiling and Tavkar, c. 5500′, 8. iv. (16030).

VERBENACEÆ.

CALLICARPA ARBOREA, *Roxb.* Above Pankabari, c. 2000′, 15. iv. (15688).

PREMNA BARBATA, *Wall.*, var. ANODON, *Clarke.* Below Pashok, c. 2800′, 20. iv. (16027).

GMELINA ARBOREA, *Linn.* Below Pashok, c. 2500′, 29. iv. (15693); Tista Valley below Temi, c. 900′, 1. v. (15691, 15692).

VITEX NEGUNDO, *Linn.* Hedges at Kalimpong, c. 4000′, 23. iv. (15694).

CLERODENDRON INFORTUNATUM, *Gaertn.* Flower; Great Ranjit, below Badantam, c. 1250′, 9. iv. (15731, 15732); fruit, above Pankabari, c. 1700′, 15. iv. (15686, 15687).

—— SERRATUM, *Spreng.* Between Badantam and the Great Ranjit, c. 1500′, 9. iv. (15817 *a*); below Pashok, c. 2500′, 20. iv. (15685); in scrub S.E. of Kalimpong, c. 2000′, 23. iv. (15817 *b*).

CARYOPTERIS PANICULATA, *C. B. Clarke.* Flower, between Darjiling and Takvar, c. 5000′, 8. iv. (16180); fruit, below Pashok, c. 3000′, 20. iv. (16029).

—— WALLICHIANA, *Schauer.* Below Badantam, c. 1500′, 9. iv. (16028).

LABIATÆ.

POGOSTEMON FRATERNUS, *Miq.* Below Gangtok, c. 5000′, 30. iv. (16138, 16139).

COLEBROOKIA OPPOSITIFOLIA, *Sm.* Below Badantam, c. 1800′, 9. iv. (15850); above Pankabari, c. 2000′, 15. iv. (15848, 15849).

MELISSA OFFICINALIS, *Linn.* Introduced? among rubbish near Tista Bridge, c. 750′, 21. iv. (16132).

LEUCOSCEPTRUM CANUM, *Sm.* Darjiling, c. 7000′, 8. iv. (15851).

AJUGA LOBATA, *D. Don.* Glen of Kulhait Chu, c. 8000′, 5. v. (16137); above Kalapokri between Tonglo and Sandakphu, c. 10,000′, 8. v. (16136).

—— MACROSPERMA, *Wall.* Near Algarah, c. 6000′, 24. iv. (16135).

—— —— var. THOMSONI, *Hook. fil.* Kalimpong, c. 4000, 23. iv. (16134).

—— —— var. BREVIFLORA, *Hook. fil.* Ibidem (16133).

PLANTAGINEÆ.

PLANTAGO MAJOR, *Linn.*, var.; different from European forms. Keuzing, c. 6000′, 2. v. (15824). Copious both in cultivated ground and in the woodland.

AMARANTACEÆ.

ÆRUA SCANDENS, *Wall.* Stony banks of Great Ranjit at Manjhitar Bridge, c. 1250′, 9. iv. (15677).

POLYGONACEÆ.

POLYGONUM ALATUM, *Buch.-Ham.*, var. NEPALENSE, *Meissn.* (pro spec.). Below Gangtok, c. 5000′, 30. iv. (16114).

—— CAPITATUM, *Buch.-Ham.* Between Kurseong and Pankabari, c. 3000′, 15. iv. (16115); near Keuzing, c. 5600′, 3. v. (16116).

—— FLACCIDUM, *Meissn.*; flores amœne rosei. Boggy ground near the Tista, c. 650′, 21. iv. (15441).

—— —— ? forma floribus albis. Tista Bridge, c. 700′, 21. iv. (15442).

—— MICROCEPHALUM, *D. Don.* Between Kurseong and Pankabari, c. 3000′, 15. iv. (16118); Pashok, c. 3400′, 20. iv. (16117).

—— PLEBEJUM, *R. Br.* River-bank at Tista Bridge, c. 650′, 21. iv. (15440).

—— RUNCINATUM, *Buch.-Ham.* Lebong, c. 5500′, 9. iv. (15443).

RUMEX NEPALENSIS, *Spreng.* Field ticket lost; (15398).

PIPERACEÆ.

HOUTTUYNIA CORDATA, *Thunb.* Near the Rahni below Gangtok, c. 2500′, 30. iv. (15820).

*PIPER ATTENUATUM, *Buch.-Ham.* Great Ranjit below Badantam, c. 1250′, 9. iv. (16235).

—— NEPALENSE, *Miq.* Glen S.E. of Kalimpong, c. 1900, 23. iv. (16236).

—— PEEPULOIDES, *Roxb.* Rishi Chu below Pedong, c. 1800′, 26. iv. (16237).

PEPEROMIA HEYNIANA, *Miq.* Damp shade above Rhikisum, c. 7300′, 25. iv. (15821).

PROTEACEÆ.

HELICIA ERRATICA, *Hook. fil.* Fruit; below Gangtok, c. 5000′, 30. iv. (15822).

LAURINEÆ.

CINNAMOMUM OBTUSIFOLIUM, *Nees.* Leaves only; Algarah, c. 6000′, 24. iv. (16131).

MACHILUS CLARKEANA, *King.* Near Sukia on the Nepal road, c. 7200′, 9. v. (16770, 16771).

—— ODORATISSIMA, *Nees.* Young fruit; ascent to Gangtok, c. 4000′, 28. iv. (16193, 16194).

PHŒBE ATTENUATA, *Nees.* Between Kurseong and Pankabari, c. 3000′, 15. iv. (16190).

—— LANCEOLATA, *Nees.* Above Pankabari, c. 2000′, 15. iv. (16189).

ACTINODAPHNE SIKKIMENSIS, *Meissn.* Young fruit; near Algarah, c. 6000′, 24. iv. (16191).

LITSEA KINGII, *Hook. fil.* Senchal, c. 8500′, 11. iv. (16192).

—— SALICIFOLIA, *Roxb.*, var. POLYNEURA, *Hook. fil.*? Kalimpong, c. 4000′, 22. iv. (16003); ibidem, c. 4500′, 24. iv. (16626, 16773).

LINDERA HETEROPHYLLA, *Meissn.* Above Chiabanjan, c. 10,500′, 5. v. (16852).

—— PULCHERRIMA, *Benth.* Senchal, c. 8000′, 11. iv. (16195, 16196, 16229, 16230).

THYMELÆACEÆ.

DAPHNE CANNABINA, *Wall.* Senchal, c. 8000′–8500′, 11. iv. (15764, 15765, 15766).

—— —— var. GLACIALIS, *Smith & Cave.* Chiabanjan, c. 10,350′, 5. v. (15763).

EDGEWORTHIA GARDNERI, *Meissn.* Gangtok, c. 6000′, 30. iv. (15767).

LORANTHACEÆ.

LORANTHUS PENTAPETALUS, *Roxb.* Between Gangtok and the Rahni, c. 3000′, 30. iv. (15818, 15819).

SANTALACEÆ.

HENSLOWIA HETERANTHA, *Hook. fil. & Thoms.* Between Gangtok and the Rahni, c. 4000′, 30. iv. (16628).

EUPHORBIACEÆ.

EUPHORBIA HIMALAYENSIS, *Boiss.* Phalut, in sward, c. 11,800′, 5. v. (16141).

—— PILULIFERA, *Linn.* By the Great Ranjit below Pemiongchi, c. 2500′, 3. v. (16142).

* The determination of these species of *Piper* is only probable.

SAUROPUS COMPRESSUS, *Muell. Arg.* Between Pankabari and Kurseong, c. 2200′, 15. iv. (16145, 16146); valley S.E. of Kalimpong, c. 2500′, 23. iv. (16144).

GLOCHIDION KHASICUM, *Hook. fil.* Below Kurseong, c. 3800′, 13. iv. (17627, 17628). There it is a very straggly bush, not a tree. Not in Gamble's list, although in Herb. Kew. there is a specimen collected by him at the same place.

PHYLLANTHUS EMBLICA, *Linn.* Below Pashok, c. 3200′, 20. iv. (15482); below Pemiongchi, c. 4000′, 3. v. (15481).

BISCHOFIA JAVANICA, *Blume.* By Rora Thong between Rhenok and Pakhyong, c. 2000′, 27. iv. (15487, 15488).

DAPHNIPHYLLUM HIMALAYENSE, *Muell. Arg.* Kalapokri between Tonglo and San-Jakphu, c. 10,000, 8. v. (15485).

CROTON CAUDATUS, *Geisel.* Tista Bridge, near river-bank, c. 700′, 21. iv. (15483).

OSTODES PANICULATA, *Blume.* Between Pedong and the Rishi Chu, c. 2500′, 26. iv. (15491, 15492).

MALLOTUS PHILIPPINENSIS, *Muell. Arg.* Fruit; below Badantam, c. 2000′, 9. iv. (15486).

CLEIDION JAVANICUM, *Blume.* Fruit; glen S.E. of Kalimpong, c. 2000′, 23. iv. (15484).

MACARANGA GUMMIFLORA, *Muell. Arg.* Great Ranjit below Badantam, c. 1250′, 9. iv. (15489); between Song and the Tista, c. 1000′, 1. v. (15490).

URTICACEÆ.

TREMA ORIENTALIS, *Blume.* Below Pashok Dak Bungalow, c. 1800′, 21. iv. (15703); near Tista below Temi, c. 900′, 1. v. (15704, 15705).

CANNABIS SATIVA, *Linn.* Escaped; Kalimpong, c. 4000′, 23. iv. (15399).

FICUS CUNIA, *Buch.-Ham.* Below Pashok, c. 2500′, 20. iv. (15377).

—— HIRTA, *Vahl.* Between the Tista and Temi, c. 1200′, 1. v. (15378, 15379).

—— HISPIDA, *Linn. fil.* Rora Thong between Rhenok and Pakhyong, c. 2000′, 27. iv. (16140).

—— MYSORENSIS, *Heyne.* Planted? Pankabari, c. 1500′, 15. iv. (15376).

—— SIKKIMENSIS, *Miq.* Glen S.E. of Kalimpong, c. 1850′, 23. iv. (16143).

CONOCEPHALUS SUAVEOLENS, *Blume.* Between Pedong and the Rishi Chu, c. 1800′, 26. iv. (16573, 16574).

LAPORTEA CRENULATA, *Gaud.* Near the Rahni below Gangtok, c. 2000′, 30. iv. (15706).

GIRARDINIA HETEROPHYLLA, *Decne.* Woods between Darjiling and Takvar, c. 5500′, 8. iv. (15707, 15708).

PILEA SMILACIFOLIA, *Wedd.* Between Kurseong and Pankabari, c. 3000′, 15. iv. (16130); glen S.E. of Kalimpong, c. 1900′, 23. iv. (16129).

—— UMBROSA, *Wedd.* Woods between Darjiling and Takvar, c. 5500′, 8. iv. (16128); near Algarah, c. 6000′, 24. iv. (16126, 16127).

ELATOSTEMA DISSECTUM, *Wedd.* Near Sangachelling, c. 6900′, 4. v. (16119).

—— HOOKERIANUM, *Wedd.* Darjiling, by the Auckland road, c. 7000′, 14. iv. (16131).

ELATOSTEMA LINEOLATUM, *Wight.* Between Kurseong and Pankabari, c. 3000′, 15. iv. (16123, 16124); glen S.E. of Kalimpong, c. 1900′, 23. iv. (16122).

—— —— var. MAJOR, *Thwaites.* Lopchu, c. 4500′, 19. iv. (16125).

—— PLATYPHYLLUM, *Wedd.* Below Pashok, c. 2500′, 20. iv. (16121).

—— REPTANS, *Hook. fil.* ? (nothing in Herb. Kew. quite matches this). Forest S.E. of Kalimpong on wet stones, c. 2500′, 23. iv. (16120).

BOEHMERIA PLATYPHYLLA, *D. Don*, var. ROTUNDIFOLIA, *Wedd.* Below Badantam, c. 2000′, 9. iv. (15702); above Rhikisum, c. 6700′, 25. iv. (15701).

JUGLANDEÆ.

ENGELHARDTIA ACERIFOLIA, *Blume.* Below Lebong, c. 5000′, 9. iv. (15479).

—— SPICATA, *Blume.* Kalimpong, c. 4000′, 22. iv. (15480).

CUPULIFERÆ.

BETULA UTILIS, *D. Don.* Above Rhikisum, c. 6900′, 25. iv. (15375).

QUERCUS LAMELLOSA, *Sm.* Young shoots, Gumpahar, c. 7000′, 13. iv. (15535); flower-spikes, above Rhikisum, c. 7500′, 25. iv. (15534).

—— ? PACHYPHYLLA, *Kurz.* Leaves and young shoots only; Senchal, 8000′–8500′, 11. iv. (15531, 15532, 15533).

—— SPICATA, *Sm.* Flower-spikes; below Badantam, c. 2500′, 9. iv. (15536, 15537).

CASTANOPSIS INDICA, *A. DC.* Young flower-spike; S.E. of Kalimpong, c. 3000′, 23. iv. (16281).

—— TRIBULOIDES, *A. DC.* Flower-spikes; between the Rahni and Ramtek Gompa, c. 5000′, 30. iv. (16261, 16262); Keuzing, c. 5800′, 2. v. (16257, 16258, 16259, 16260).

CONIFERÆ.

ABIES WEBBIANA, *Lindl.* Senchal (planted), c. 8500′, 11. iv. (15286); Sandakphu, c. 12,000′, 7. v. (15284); Subarkum, c. 11,000′, 7. v. (15285).

TAXUS BACCATA, *Linn.* North slope of Tonglo, c. 9000′, 8. v. (15287).

ORCHIDEÆ.

DENDROBIUM DENSIFLORUM, *Wall.* Between Rora Thong and Pakhyong, c. 2500′, 27. iv. (15563, 15564).

—— FIMBRIATUM, *Hook. fil.*, var. OCULATUM, *Hook. fil.* Below Pakhyong, c. 3500′, 28. iv. (15520).

—— FUSCESCENS, *Griff.* Above Lopchu, c. 5000′, 19. iv. (16265).

—— NOBILE, *Lindl.* Between Rora Thong and Pakhyong, c. 2500′, 27. iv. (15565, 15566).

—— PIERARDI, *Roxb.* Below Pedong, c. 2500′, 26. iv. (15552*a*); by the Rora Thong between Rhenok and Pakhyong, c. 1900′, 27. iv. (15552*b*); below Pemiongchi near Jhirghni, c. 3000′, 3. v. (15521).

ERIA CONFUSA, *Hook. fil.* Below Pemiongchi, c. 4500′, 3. v. (15525, 15526).

—— PANNEA, *Lindl.* Above the Rahni below Gangtok, c. 2500′, 30. iv. (16266).

PHAIUS MACULATUS, *Lindl.* Pashok, in the garden, 20. iv. (15522).

—— WALLICHII, *Lindl.* Pashok, in the garden, 20. iv. (15523, 15524).

Cœlogyne corymbosa, *Lindl.* Between Chiman and Jorepokri, c. 7000′, 9. v. (16271, 16272).

—— cristata, *Lindl.* Near Lopchu, c. 4500′, 19. iv. (16273).

—— ochracea, *Lindl.* Between the Roro Chu and Gangtok, c. 2500′, 28. iv. (16269, 16270); near Ramtek Gompa, c. 6000′, 30. iv. (16267, 16268).

Cremastra Wallichiana, *Lindl.* Near Jorepokri Dak Bungalow, c. 7300′, 9. v. (15554).

Galeola Hydra, *Reichb. fil.* Boggy ground below Pashok, c. 2500′, 20. iv. (16274).

Spiranthes australis, *Lindl.* Grassy places above Lebong, c. 6000′, 9. iv. (15530).

Goodyera procera, *Hook.* Boggy ground below Pashok, c. 2500′, 20. iv. (16263, 16264).

SCITAMINEÆ.

Cautleya Cathcarti, *Baker.* Kulhait Chu, c. 7000′, 5. v. (16251).

Hedychium Gardnerianum, *Rosc.* Fruit; Lopchu, c. 4500′, 19. iv. (16249).

—— thyrsiforme, *Buch.-Ham.* Fruit; by the Great Ranjit below Badantam, c. 1250′, 9. iv. (16250).

Curcuma Zedoaria, *Rosc.* Below Pashok, c. 2500′, 20. iv. (15558); near the Tista below Temi, c. 1200′, 1. v. (15557).

HÆMODORACEÆ

Peliosanthes macrophylla, *Wall.* Below Kurseong, c. 3800′, 15. iv. (15548, 15549).

Ophiopogon Clarkei, *Hook. fil.*; showing the root-tubers, which have not been preserved in any Kew specimen, and apparently were unknown to Hooker; it is *not O. Wallichianus* or *O. intermedius.* Senchal, c. 8000′, 11. iv. (16245, 16246).

IRIDEÆ.

Iris Clarkei, *Baker.* Old capsules and young leaves only; very plentiful on the summit of Tonglo, c. 10,500′, 8. v. (15547).

AMARYLLIDEÆ.

Curculigo gracilis, *Wall.* Near Algarah, c. 6000′, 24. iv. (16238).

LILIACEÆ.

Smilax elegans, *Wall.* North slope of Tonglo, c. 9000′, 8. v. (16242).

—— ferox, *Wall.* Near Jorepokri Dak Bungalow, c. 7400′, 9. v. (16241).

—— macrophylla, *Roxb.* Near the Great Ranjit below Badantam, c. 1250′, 9. iv. (16244); between Pashok and Tista Bridge, c. 1200′, 21. iv. (16243).

Polygonatum cirrifolium, *Royle.* Below Pemiongchi, c. 6000′, 3. v. (15550).

—— oppositifolium, *Royle.* Leaves firm, sheaths not conspicuous; near Lopchu, c. 4500′, 19. iv. (16247).

—— Cathcarti, *Baker?* or a mere shade form of *oppositifolium?*; leaves very flaccid and the transverse veinlets obscure; sheaths very conspicuous; from the Kew specimens I am inclined to doubt the validity of this species. Above Lopchu, c. 5000′, 19. iv. (16248).

Smilacina fusca, *Wall.* Near Sukia, c. 7000′, 9. v. (15538); above Rhikisum, c. 7500′, 25. iv. (15539, 15540).

SMILACINA OLERACEA, *Hook. fil. & Thoms.* Near Jorepokri Dak Bungalow, c. 7100′, 9. v. (15541, 15542).

LILIUM GIGANTEUM, *Wall.* Leaf and capsule only; north slope of Tonglo, c. 9000′, 8. v. (15567, 15568). Very plentiful in the Kulhait Chu glen.

FRITILLARIA CIRRHOSA, *D. Don.* Sandakphu, c. 11,500′, 7. v. (15551).

DISPORUM PULLUM, *Salisb.* Above Rhikisum, c. 7100′, 25. iv. (15527, 15528, 15529); Demthang forest above Temi, c. 6000′, 2. v. (15555, 15556).

PARIS POLYPHYLLA, *Sm.* Gumpahar, c. 6750′, 13. iv. (15543); Senchal, c. 8000′, 11. iv. (15545 A); Rhikisum, c. 6400′, 24. iv. (15544); Kalapokri, between Tonglo and Sandakphu, c. 10,000′, 8. v. (15545).

COMMELYNACEÆ.

COMMELYNA NUDIFLORA, *Linn.* Tista Bridge near river-bank, c. 700′, 21. iv. (16254).

—— OBLIQUA, *Buch.-Ham.* Near the Tista below Temi, c. 1000′, 1. v. (16252, 16253).

AROIDEÆ.

POTHOS SCANDENS, *Linn.* Glen S.E. of Kalimpong, c. 1900′, 23. iv. (15559, 15560).

RHAPHIDOPHORA DECURSIVA, *Schott.* Below Pakhyong, c. 2500′, 28. iv. (16239, 16240).

THOMSONIA NEPALENSIS, *Wall.* Near Tista Bridge, c. 750′, 21. iv. (16203); Rora Thong between Rhenok and Pakhyong, c. 1900′, 27. iv. (16201, 16202).

RICHARDIA AFRICANA, *Kunth.* Escaped; near Ghoom village, c. 7500′, 13. iv. (16197).

ALOCASIA FALLAX, *Schott.* Above Pakhyong, c. 4800′, 27. iv. (16200).

—— MACRORHIZA, *Schott.* Below Pakhyong, c. 4000′, 27. iv. (16198, 16199).

ARISÆMA CONCINNUM, *Schott.* Algarah, c. 6000′, 24. iv. (16221); Rhikisum, c. 6400′, 24. iv. (16220); Pemiongchi, c. 6900′, 3. v. (16227); Kulhait Chu, c. 7000′, 5. v. (16222, 16223); (the last rather a peculiar form).

—— CONSANGUINEUM, *Schott.* Below Chiman on the Nepal road, c. 7000′, 9. v. (16282).

—— GALEATUM, *N. E. Brown.* Algarah, c. 6000′, 24. iv. (16213, 16214, 16215).

—— GRIFFITHII, *Schott.* Senchal, c. 8000′, 11. iv. (16204, 16205); Kulhait Chu glen, c. 8000′, 5. v. (16206).

—— HELLEBORIFOLIUM, *Schott* (*not* identical with *A. tortuosum*). Between Temi and Demthang, c. 5500′, 2. v. (16217); Pemiongchi, c. 6900′, 3. v. (16219).

—— NEPENTHOIDES, *Mart.* Demthang forest, c. 6500′, 2. v. (16225, 16226); head of Kulhait Chu glen, c. 8500′, 5. v. (16224).

—— SPECIOSUM, *Mart.* Gumpahar, c. 7000′, 13. iv. (16209, 16210).

—— OCHRACEUM, *Schott*? Summit of Tonglo, c. 10,500′, where it is extremely plentiful, to the exclusion of other kinds of *Arisæma*, 8. v. (16228). It should therefore be *A. ochraceum* '*ex loco*,' but the presence of appendages at the base of the lamina of the spathe point to its being more probably a small form of *A. nepenthoides*. Hooker's original drawing of *A. ochraceum* at Kew does not show these appendages, although it agrees with my

specimens in colouring and other respects. The type specimen of *A. ochraceum* no longer exists, at any rate at Kew.

ARISÆMA VERRUCOSUM, *Schott.* In the open above Chiabanjan, c. 10,500′, 5. v. (16207, 16208). The leaf-edges are golden coloured and crinkled as in *A. affine*, of which I suspect it to be a mere *lusus*. In life it is quite unlike *A. Griffithii.*

—— WALLICHIANUM, *Hook. fil.* Phalut, in Rhododendron forest, c. 11,600′, 6. v. (16216).

CYPERACEÆ.

MARISCUS SIEBERIANUS, *Nees.* Above the Tista below Temi, c. 1400′, 1. v. (16283).

—— —— var. EVOLUTIOR, *C. B. Clarke.* Below Pashok, c. 3000′, 20. iv. (16279, 16280).

—— CYPERINUS, *Vahl*, var. BENGALENSIS, *C. B. Clarke.* Below Pashok, c. 2500′, 20. iv. (16284).

KYLLINGA BREVIFLORA, *Rottb.* Pashok tea-garden in boggy ground, c. 2500′, 20. iv. (15670); Tista Bridge near the river, c. 650′, 21. iv. (16211).

CAREX CRUCIATA, *Wall.* Below Pakhyong, c. 2500′, 28. iv. (16570).

—— POLYCEPHALA, *Boott.* North slope of Tonglo, c. 9000′, 8. v. (16571).

—— VESICULOSA, *Boott.* Between Ramtek Gompa and Murtam, c. 6000′, 30. iv. (16572).

GRAMINEÆ.

THYSANOLÆNA AGRESTIS, *Nees.* Near the Great Ranjit below Badantam, c. 1250′, 9. iv. (15444, 15450).

FILICES.

GLEICHENIA GLAUCA, *Hook.* Darjiling, c. 7000′, 8. iv. (15894, 15895).

—— LINEARIS, *C. B. Clarke.* Above Pankabari, c. 2000′, the lowest limit, 15. iv. (15897); above Pashok, c. 4000′ (15896).

ALSOPHILA OLDHAMI, *Bedd.* I leave this under this name because the veins are all simple, whereas in *A. ornata*, to which Beddome himself reduced *Oldhami* later, they are forked according to the description, and forked in the specimens I have seen at Kew and the British Museum. The importance of this as a specific character requires further study on the spot to see whether it is supported by differences in the stipes. Between Darjiling and Takvar, c. 5500′, 8. iv. (15784, 15785).

DIACALPE ASPIDIOIDES, *Blume.* Senchal, 8000′–8200′, 11. iv. (16618, 16619, 16620, 16621).

PERANEMA CYATHIOIDES, *D. Don.* Darjiling near the "Calcutta" road, c. 7000′, 11. iv. (15949, 15950); between Ramtek Gompa and Song, c. 6000′, 30. iv. (16624).

DENNSTAEDTIA SCABRA, *T. Moore.* East of Jore bungalow, c. 7000′, 19. iv. (15951, 15952); above Rhikisum, c. 7500′, 25. iv. (16617); above Pakhyong, c. 4800′, 27. iv. (16614, 16615); Demthang forest, c. 6500′, 2. v. (16612, 16613).

HYMENOPHYLLUM EXSERTUM, *Wall.* Senchal, on stones, c. 8500′, 11. iv. (16810, 16811); north slope of Tonglo, on wet rocks, c. 9000′, 8. v. (16809).

HYMENOPHYLLUM POLYANTHOS, *Sw.* Demthang forest, c. 6000′, 2.v. (16806); Sandakphu, on dripping rocks in a glen, c. 11,500′, 7.v. (16807, 16808). This last is a large form differing in appearance from that figured by Beddome.

TRICHOMANES RADICANS, *Sw.* Below Pakhyong, in a dripping gully, c. 3800′, 28.iv. (16812, 16813).

ACROPHORUS STIPELLATUS, *T. Moore.* Between Darjiling and Takvar, c. 5500′, 8.iv. (16631, 16632).

DAVALLIA BULLATA, *Wall.* Below Pakhyong, c. 4000′, 27.iv. (16623).

MICROLEPIA. The following four ferns belong to an exceedingly confused group. Baker, Beddome, and Clarke are at complete variance in their treatment of *strigosa*, *hirta*, *Speluncæ*, *flaccida*, and their forms. I am convinced that a reduction of the forms to one or two species only is a mere counsel of despair. They are very large ferns, the habit of which is completely obscured in herbarium specimens. Some seem to frequent relatively dry scrub, others to prefer boggy ground. The true relationships of the Sikkim forms, not to speak of others, can only be determined by careful observation on the spot by a botanist already acquainted with the problem so as to note the exact points at issue in each case. So far as I can judge, Clarke's knowledge of the North Indian forms was more intimate than Beddome's, and his treatment of them more trustworthy. It is unfortunately confused by his having overlooked the fact that some of the specimens distributed by Wallich do not agree, even in genus, with the corresponding numbers in his own herbarium. None of the authors seems to have taken notice of the different position of the sori in some of these ferns. I venture to call attention to this so far as regards my own specimens, but have not had time to work carefully through all those at Kew and the British Museum from that point of view.

MICROLEPIA PILOSULA, *Presl* (Wall. Cat. 263, sub *Davallia*)=*Davallia polypodioides*, D. Don, var. *pilosula*, C. B. Clarke=*Microlepia Speluncæ*, Linn., var. *hirta* forma *pilosula*, Bedd. (but not *Davallia flaccida*, var. *pilosula*, C. B. Clarke, which is based on *Aspidium pilosulum*, Wall. Cat. 337, *i. e.* on Wallich's specimen bearing no. 337 in Herb. Hook. at Kew, the no. 337 in Wallich's own herbarium, although labelled *A. pilosulum*, being really *Nephrodium* (§ *Lastrea*) *crenatum*, to which it is correctly referred by Clarke himself elsewhere (Fl. Ind. pp. 525 and 602), as well as by Beddome, Handbook, p. 258).

This fern differs from *M. Speluncæ* and *M. flaccida*, and consequently from the rest of my *Microlepia* specimens, by its slightly stiffer texture with more strigose hairs and more prominent veins beneath the frond, but more markedly by the position of the sori which are terminal on the veinlet and consequently quite marginal, one at each notch of the serrated pinnule. Rhikisum, c. 6500′, 24.iv. (16629, 16630).

—— PUBERULA, *mihi* (*Davallia puberula*, Wall. Cat. n. 262)=*Davallia flaccida*, var. *puberula*, C. B. Clarke=*Microlepia Speluncæ*, var. *hirta* forma *puberula*, Bedd. This differs from *M. pilosula*, Presl in texture, being softer, and in

segmentation, but especially in the position of the sori, which are not marginal, but placed at the last bifurcation of the veins. Below Badantam, c. 1800′, 9. iv. (16794, 16795, 16796).

MICROLEPIA PUBERULA, forma PILOSIOR, *mihi* = *Davallia flaccida* var. *pilosula*, C. B. Clarke, which he bases on the Wallichian specimen in Herb. Hook. bearing the number 337 and the name *Aspidium pilosulum*. But the no. 337 *Aspidium pilosulum* of Wallich's own herbarium is (as mentioned above) *Nephrodium crenatum*! Even if the plant in Herb. Hook. were to be regarded as the type of no. 337, it could not, when transferred to *Microlepia* (or *Davallia*) bear the name of *pilosula*, because that properly belongs to *Davallia pilosula*, Wall. Cat. n. 263. In this specimen the sori are nearer the margin than in the last, but still within it. Both are very large ferns, growing in moderately dry spots, and bear a superficial resemblance to *Phegopteris ornata*, but without the characteristic rough scales on the stipe and rhachis. Forest S.E. of Kalimpong, c. 2000′, 25. iv. (16790, 16791, 16792).

—— PYRAMIDATA, *mihi* (*Davallia pyramidata*, Wall. Cat. n. 261) = *Davallia flaccida* var. *pyramidata*, C. B. Clarke = *Microlepia Speluncæ* var. *hirta* forma *pyramidata*, Bedd. This, as Clarke says, is a critical form. If, as seems probable, it is identical with *Davallia pilosa*, Roxb. in Calc. Journ. iv. p. 515 (1844) and Fl. Ind. p. 761, of which the original drawing, but no herbarium specimen, is at Kew, Roxburgh's specific name will be entitled to preference. The whole fern is softer and hairier, and the pinnules and their ultimate segments much broader than in *M. puberula*. The soft texture, the immersed veins, and, above all, the position of the sori, which are not marginal but median, situated at the last bifurcation of the veins little more than half-way from the costa to the margin, one corresponding to each notch of the pinnule, seem quite sufficient to separate this fern specifically from *M. pilosula*, Presl, and from many specimens which are referred to *M. hirta* and *M. Speluncæ*. Boggy ground below Pashok, c. 2500′, 20. iv. (16857, 16858, 16859).

STENOLOMA CHINENSIS, *Bedd.* Below Kalimpong, 2500′–3500′, 23. iv. (15965, 15968); above Pakhyong, c. 4800′, 27. iv. (15964); below Pakhyong, c. 4000′, 28. iv. (15967); below Gangtok, c. 6000′, 30. iv. (15966).

LINDSAYA CULTRATA, *Sw.* Between Darjiling and Takvar, c. 5500′, 8. iv. (15926); Gumpahar, c. 7200′, 13. iv. (15927).

—— —— forma ad var. *Lobbianum* vergens; Gumpahar, c. 7200′, 13. iv. (15928).

ADIANTUM CAUDATUM, *Linn.*; a form with pinnæ resembling *A. Edgeworthii*, but it is only subglabrescent not glabrous. Below Pashok, c. 2500′, 20. iv. (16633).

CHEILANTHES FARINOSA, *Kaulf.* Between Kurseong and Pankabari, c. 3000′, 15. iv. (16622).

ONYCHIUM AURATUM, *Kaulf.* By Manjhitar Bridge on the Great Ranjit, c. 1250′, 9. iv. (15945, 15946); above Pankabari, c. 2000′, 15. iv. (15947, 15948).

PTERIS CRETICA, *Linn.* Between Lopchu and Pashok, c. 4000′, 19. iv. (15958, 15959); at Song, c. 6000′, 1. v. (15957).

PTERIS LONGIFOLIA, *Linn.* Glen above Tista Bazar, c. 850′, 21. iv. (15956).

—— LONGIPES, *D. Don.* Near Algarah, c. 6000′, 24. iv. (15960, 15961).

—— QUADRIAURITA, *Retz.* Gumpahar, c. 7000′, 13. iv. (16637).

—— ASPERICAULIS, *Wall.* The harsh texture of this fern, and the form of the ultimate pinnules, as well as the reddish colour of the young fronds, seem to me to distinguish it quite satisfactorily from *P. quadriaurita.* Algarah, c. 6000′, 24. iv. (16778, 16779).

—— (§ CAMPTERIA) BIAURITA, *Linn.* This is really much nearer *quadriaurita* than *aspericaulis* is. Below Badantam, c. 2500′, 9. iv. (15995, 15996).

—— (§ CAMPTERIA) WALLICHIANA, *Agardh.* Between Kurseong and Pankabari, c. 3000′, 15. iv. (15994).

PLAGIOGYRA PYCNOPHYLLA, *Mett.* Senchal, c. 8200′, 11. iv. (15954, 15955); above Rhikisum, c. 7500′, 25. iv. (15953).

BLECHNUM ORIENTALE, *Linn.* By the Great Ranjit below Badantam, c. 1260′, 9. iv. (15917).

WOODWARDIA RADICANS, *Sm.* Pashok garden, brought from neighbouring glen, c. 3400′, 20. iv. (15979).

THAMNOPTERIS NIDUS, *Presl.* Below Pakhyong, c. 3000′, 28. iv. (15886, 15887).

ASPLENIUM ENSIFORME, *Wall.* Above Rhikisum, c. 7500′, 25. iv. (16611); Kulhait Chu, c. 8000′, 5. v. (15888).

—— CHEILOSORUM, *Kuntze* (*heterocarpum*, Wall.). Below Pashok, c. 2500′ (15882); below Pakhyong, c. 3800′, 28. iv. (15883).

—— LACINIATUM, *D. Don.* Demthang forest, c. 6000′, 2. v. (15884).

—— UNILATERALE, *Lam.* Between Pashok and the Tista (leg. Lister), c. 2000′ (16606, 16607).

—— —— var. UDUM, *Atkinson.* Ibidem (16605).

—— TENUIFOLIUM, *D. Don.* Gumpahar, c. 7000′, 13. iv. (15885).

ATHYRIUM NIGRIPES, *T. Moore.* Above Rhikisum, c. 7400′, 25. iv. (16598).

DIPLAZIUM STOLICZKÆ, *Bedd.*, var. HIRSUTIPES, *Bedd.* Senchal, c. 8200′, 11. iv. (16638, 16639).

—— POLYPODIOIDES, *Blume*? In the absence of the caudex I am uncertain whether this should not be referred to *D. multicaudatum*, Wall.; it may perhaps be *D. sikkimense*, Clarke. Below Pashok, c. 3000′, 20. iv. (16601, 16602, 16603).

—— MAXIMUM, *C. Christn.* (*Asplenium latifolium*, D. Don *non* Cav.). Rhikisum, south slope, c. 6500′, 24. iv. (16643, 16644, 16645); north slope, c. 6000′, 26. iv. (16640, 16641).

—— ESCULENTUM, *Sw.* (*Aspidium*, C. B. Clarke); ex loc. class. and compared with Clarke's type, but I suspect Clarke's species to be a mere variation of *D. maximum.* It should be further studied on the spot. Gumpahar, c. 7000′, 13. iv. (17629, 17630, 17631, 17632).

ANISOGONIUM ESCULENTUM, *Presl.* Boggy ground below Pashok, c. 2500′, 20. iv. (16608).

DIPLAZIOPSIS JAVANICA, *C. Christn.* (*Allantodia*, Trev.). Below Pakhyong, c. 3800′ 28. iv. (16609, 16610).

POLYSTICHUM ACULEATUM, *Schott*, var. SEMIFERTILE, *C. B. Clarke.* Algarah, c. 6000′, 24. iv. (15990).

POLYSTICHUM ACULEATUM, var. SETOSUM, *Wall.* pro specie. Senchal, c. 8000′, 11. iv. (15861, 15993); above Rhikisum, c. 7500′, 25. iv. (15992).

—— —— var. RUFOBARBATUM, *Wall.* pro specie. Rhikisum, c. 6800′, 24. iv. (15991).

—— AURICULATUM, *Presl.* Between Darjiling and Takvar, c. 5500′, 8. iv. (15983).

—— —— var. LENTUM, *D. Don*, pro specie. Below Gangtok, c. 5000′, 28. iv. (15984).

—— —— var. OCELLATUM, *Wall.* (compared with Wallich's type no. 360). Senchal, c. 8500′, 11. iv. (15986, 15987).

—— —— var. MARGINATUM, *Wall.* Senchal, c. 8200′, 11. iv. (15985); rocks below Chiabanjan, c. 9500′, 5. v. (15988, 15989).

LASTREA CALCARATA, *T. Moore*, var. FALCILOBA, *C. B. Clarke.* Between Darjiling and Takvar, c. 5000′, 8. iv. (15905, 15906).

—— CONIIFOLIA, *T. Moore.* Glabrous form, drying green; Senchal, c. 7800′, 11. iv. (16579, 16580).

—— —— Ditto, but the stipe only paleaceous; between Darjiling and Takvar, c. 5000′, 8. iv. (15873, 15874, 15875).

—— —— Drying brown, all rhachis paleaceous; above Pakhyong, c. 4800′, 27. iv. (15876, 15877).

—— PATENTISSIMA, *Presl.* Above Rhikisum, c. 7000′, 25. iv. (15908, 15909, 15910).

—— SPLENDENS, *Bedd.* Large form; Senchal, c. 8000′, 11. iv. (15919, 15920, 15921, 15922, 15923); small form, ibidem (15907).

NEPHRODIUM ARIDUM, *Sm.* Near the Great Ranjit below Badantam, c. 1250′, 9. iv. (15937, 15938, 15939).

—— CRINIPES, *Hook.* Below Pashok, c. 2500′, 20. iv. (16780, 16781, 16782, 16783).

—— MOLLIUSCULUM, *Bedd.* Below Pashok, c. 2500′, 20. iv. (16634).

—— MOULMEINENSE, *Bedd.* Below Badantam, c. 2500′, 9. iv. (15940, 15941).

ASPIDIUM CICUTARIUM, *Sw.* Pashok, c. 2000′ (leg. Lister) (15872).

—— POLYMORPHUM, *Wall.* Near Tista Bridge (leg. Lister), c. 800′ (15872); glen S.E. of Kalimpong, c. 1800′, 23. iv. (15880, 15881); near the Rahni below Gangtok, c. 2000′, 30. iv. (15878).

PLEOCNEMIA MEMBRANIFOLIA, *Bedd.* (?) In the glen S.E. of Kalimpong, c. 1800′, 23. iv. (17633, 17634). This is a form half-way to *Acrostichum* (§ *Stenosemia*) *auritum*. It is much nearer *A. auritum* than to Clarke's var. *dimorpha* (Ferns N. Ind. in Trans. Linn. Soc. ser. 2. Bot. i. (1880) p. 535, plate 74. figs. B & C), but not so near as Scortechini's Malayan specimens referred to in Beddome's Suppl. p. 48, the fertile frond-segments not being quite so narrow as in those.

NEPHROLEPIS CORDIFOLIA, *Presl*, forma marginibus subintegris. Great Ranjit below Badantam, c. 1250′, 9. iv. (15942).

OLEANDRA WALLICHII, *Presl.* Gangtok, c. 6500′, 30. iv. (15943, 15944).

PHEGOPTERIS AURICULATA, *Sm.* Gumpahar, c. 7000′, 13. iv. (15980, 15981, 15982).

—— ORNATA, *Fée.* Below Badantam, c. 1800′, 9. iv. (16793); ibidem, by the Great Ranjit, c. 1250′ (16797, 16798, 16799); valley S.E. of Kalimpong, c. 2000′, 23. iv. (16786, 16787, 16788, 16789).

PHEGOPTERIS PUNCTATA, *Mett.* Keuzing, in open scrub, c. 6000′, 2. v. (16635, 16636).

MONACHOSORUM SUBDIGITATUM, *Kuntze* (*Phegopteris*, Beddome). Senchal, c. 8000′, 11. iv. (15862, 16584); between Pemiongchi and Sangachelling, c. 6800′, 4. v. (16597).

GONIOPTERIS UROPHYLLA, *Presl.* Between Ramtek Gompa and Murtam, c. 6000′, 30. iv. (15935, 15936).

GONIOPHLEBIUM AMŒNUM, *J. Sm.* Between Rhikisum and Pedong, c. 5800′, 26. iv. (15898); between the Roro Chu and Gangtok, c. 4000′, 28. iv. (15899, 15900).

NIPHOBOLUS ADNASCENS, *Kaulf.* Near Pashok (leg. Lister), c. 3000′ (16587); between Song and the Tista, c. 2000′, 1. v. (16592, 16593); below Keuzing, c. 2000′, 3. v. (16590, 16591).

—— BEDDOMEANUS, *Gies* (*Polypodium costatum*, Wall.). Between Song and the Tista, c. 3000′, 1. v. (16592, 16593).

—— HETERACTIS, *J. Sm.* Between Pemiongchi and Sangachelling, c. 6900′, 4. v. (16586).

—— NUMMULARIÆFOLIUM, *J. Sm.* Below Pashok, c. 3000′, 21. iv. (16576).

—— POROSUS, *Presl.* Between Pashok and the Tista (leg. Lister), c. 2000′ (16577); near Sangachelling, c. 6600′, 4. v. (16578).

LEPTOGRAMME AURITA, *Bedd.* Soshing Gompa above Keuzing, c. 6000′, 2. v. (15924, 15925).

GYMNOGRAMME MICROPHYLLA, *Hook.* Senchal, on stones, c. 8000′, 11. iv. (15901).

CEROPTERIS CALOMELANOS, *Underw.* In a rocky gully above the road from Tista Bazar to Pashok, c. 1000′, 21. iv. (16775, 16776, 16777).

The presence of this fern below Pashok has long been known to Mr. Lister of Pashok, and it has been observed there by others, but does not seem to have been recorded. It is very plentiful at the spot where I found it, which is quite in the jungle and miles from any garden. Mr. Lister writes as follows on the 18th Jan. 1914 :—"I am interested in the fern you collected on the south of Pashok, which seems to have been overlooked by Beddome. Many years ago I tried to bring under tea cultivation the site of an old copper smelting kiln, where there was a thick coating of refuse, and one of the common weeds that appeared was the mealy fern." If the fern referred to was really *calomelanos*, the presence of the spores in the soil at such a place remains quite unexplained. It is not the case of seeds that may be carried great distances by birds. In the Calcutta herbarium there are specimens "naturalised" from Mercara, Coorg, as well as from Java and Malacca, and in Aldeverelt van Rosenburgh's 'Handbook of Malayan Ferns' (1909) *calomelanos* is stated to occur not infrequently as an escape in the neighbourhood of gardens. But there is not and never was any garden near the glen above the Tista.

DRYNARIA PROPINQUA, *J. Sm.* Below Pashok, c. 3000′, 19. iv. (15891, 15892); ibidem, c. 2600′, 20. iv. (15893); near Song, c. 5000′, 1. v. (15889, 15890).

—— CORONANS, *Bedd.* Between Badantam and the Great Ranjit, c. 1800′, 9. iv. (15918); below Pashok, c. 2500′ (15913, 15914, 15915).

DIPTERIS WALLICHII, *T. Moore.* Rampokri in the Daling district (leg. Lister) (15916).

PLEOPELTIS SUBROSTRATA, *mihi* (*Polypodium subrostratum*, C. Christn.) = *P. rostrata*, Bedd. Above Keuzing, c. 6000′, 2. v. (16009, 16010).

—— LINEARIS, *T. Moore*. Senchal, 8000′–8500′, 11. iv. (16004, 16006, 16007); Gumpahar, c. 7000′, 13. iv. (16005 *a*); between Song and the Tista, c. 3000′, 1. v. (16008); Tonglo, c. 9000′, 8. v. (16005 *b*).

—— EXCAVATA, *T. Moore* = *simplex*, Bedd. Near Pashok, leg. Lister (15997); glen of the Kulhait Chu, c. 7000′, 5. v. (15998).

—— LONGIFOLIA, *Blume*. Senchal, c. 8000′, 11. iv. (16000); above Keuzing, c. 6000′, 2. v. (16001, 16002); below Chiabanjan, c. 9000′, 5. v. (15999).

—— LONGIFRONS, *T. Moore* = *normalis*, T. Moore, var. *sparsisora*, Bedd. Above Rhikisum, c. 6700′, 25. iv. (16018); between Temi and Demthang, c. 5500′, 2. v. (16016, 16017); above Manepanjan, c. 7800′, 9. v. (16015).

—— RHYNCOPHYLLA, *T. Moore*. Between Ramtek Gompa and Murtam, c. 6000′, 30. iv. (16011).

—— GRIFFITHIANA, *T. Moore*. Darjiling by the "Calcutta" road, c. 7200′, 11. iv. (16013); by the "Auckland" road, c. 7200′, 14. iv. (16012); above Manepanjan, c. 7800′, 9. v. (16014).

—— MEMBRANACEA, *T. Moore*. Below Pakhyong, c. 3800′, 28. iv. (16020).

—— PUNCTATA, *Bedd*. Rocks above Tista Bazar, c. 800′, 21. iv. (16019, 17696).

—— JUGLANDIFOLIA, *T. Moore*. Gumpahar, c. 7000′, 13. iv. (16022, 16023).

—— HIMALAYENSIS, *Bedd*. Glen of the Kulhait Chu, c. 8500′, 5. v. (16021).

—— LEIORHIZA, *T. Moore*. Below Badantam, c. 2000′, 9. iv. (16024); between Kurseong and Pankabari, c. 3000′, 15. iv. (15867); below Pashok, c. 2500′, 20. iv. (16025, 16026).

SYNGRAMME FRAXINEA, *Bedd.*; forma pinnata, pinnarum marginibus cartilagineis integris = *Gymnogramme javanica*, Blume. Between Kurseong and Pankabari, c. 3000′, 15. iv. (15972, 17697).

—— —— forma pinnis latis = *Gymnogramme javanica* var. *latifolia*, Blume. Between Keuzing and the Great Ranjit, c. 2500′, 3. v. (15969, 15970, 15971).

—— —— forma bipinnata marginibus serrulatis = *Gymnogramme serrulata*, Blume. Above Rhikisum, c. 6900′, 25. iv. (15973).

I am not convinced by the authority even of Beddome and Clarke that *G. javanica* and *G. serrulata* are mere variants of one species. They should be much more carefully studied on the spot, and the margin of the frond as well as the dissection considered.

LOXOGRAMME INVOLUTA, *Presl*. Below Pashok (leg. Lister) (15929).

SELLIGUEA ELLIPTICA, *Bedd*. Between Darjiling and Takvar, c. 5000′, 8. iv. (15962, 15963).

ANTROPHYUM LATIFOLIUM, *Blume*. Near Pashok, leg. Lister (15871).

VITTARIA ELONGATA, *Sw*. Between the Roro Chu and Gangtok, c. 3000′, 28. iv. (15975).

—— LINEATA, *Sm*. Between Song and the Tista, c. 3000′, 1. v. (15978).

—— SCOLOPENDRINA, *Thwaites*. Below Pakhyong, c. 3000′, 28. iv. (15977).

—— SIKKIMENSIS, *Kuhn*. Below Pakhyong, c. 3000′, 28. iv. (15976).

Elaphoglossum conforme, *Schott.* Between Gangtok and the Rahni, c. 3000', 30. iv. (15974).

—— viscosum, *Schott.* Between Ramtek Gompa and Murtam, c. 6000', 30. iv. (16595, 16596); Sangachelling, c. 7000', 4. v. (16594).

Polybotrya appendiculata, *Sm.* Pashok, leg. Lister (16604, 16616).

Leptochilus scalpturatus, *C. Christn.* = *Gymnopteris costata*, Bedd.; this form precisely = *Meniscium deltigerum*, Wall. Glen S.E. of Kalimpong, c. 1800', 22. iv. (15932, 15933, 15934).

Gymnopteris spicata, *Presl.* Near the Tista below Pashok, leg. Lister (15902).

—— tricuspis, *Bedd.* (*Leptochilus*, C. Christn.). Between Song and the Tista, c. 3000', 1. v. (15904).

—— flagellifera, *Bedd.* = *Leptochilus heteroclitus*, C. Christn. Glen S.E. of Kalimpong, c. 1800', 23. iv. (15903, 17698).

Lygodium circinnatum, *Sw.* Near Tista Bazar, c. 750', 21. iv. (15931).

—— japonicum, *Sw.* Below Pakhyong, c. 3000', 28. iv. (15930).

Angiopteris evecta, *Hoffm.* Near Lopchu, c. 4000', 19. iv. (15863, 15864, 15865, 15866); near the Roro Chu between Pakhyong and Gangtok, c. 2000', 28. iv. (15869, 15870).

Botrychium daucifolium, *Wall.* Below Rhikisum, c. 6000', 26. iv. (16255, 16256).

Lycopodium clavatum, *Linn.* Ascent from Dentam to Mongthang, c. 5500', 5. v. (16802); glen of the Kulhait Chu, c. 8500', 5. v. (16801).

—— squarrosum, *Forst.* (exactly *L. ulicifolium*, Venten.). On a tree by the Roro Chu below Gangtok, c. 2000', 28. iv. (16800).

Selaginella caulescens, *Spring.* Near Keuzing, c. 5600', 2. v. (16805).

—— plumosa, *Baker.* Below Darjiling, c. 6500', 8. iv. (16804); below Pakhyong, c. 3800', 28. iv. (16803).

I have to thank Mr. J. S. Gamble, F.R.S., for the following descriptions of two plants mentioned on p. 464, extracted from a forthcoming article in the 'Kew Bulletin.'—C. C. L., 7th December, 1916.

Skimmia arborescens, *T. And.* MS. in Herb. Kew. *Arbor* parva ad 5 m. alta; ramuli crassi, glabri, pallidi. *Folia* persistentia, carnosa, siccitate fere membranacea, glabra, oblanceolata, cuspidato-acuminata, 10–18 cm. longa, 2·5–5 cm. lata, nervis primariis siccitate conspicuis utrinque 6–7 marginem versus arcuatim junctis; petioli crassi, anguste alati, 1·2–2 cm. longi. *Flores* albidi-virentes, dioici, in paniculis subterminalibus sessilibus, 2–4 cm. longis, minute puberulis; bracteæ bracteolæque ovato-acutæ ciliatæ. *Calycis* lobi 5, ovati, ciliati, 2 mm. longi. *Petala* 5, subinæqualia, oblanceolata, 6 mm. longa. *Stamina* petalis æquilonga, in floribus ♀ minora. *Ovarium* in ♂ minutum, stylis 3 gracilibus brevibus; in ♀ globosum, stylo erecto, glabro, 2–3 mm. longo, stigmate capitato. *Fructus* niger, globosus, carnosus, circa 7 mm. diametro, pyrenis 3 crustaceis pendulis.

East Nepal, *J. D. Hooker*, no. 94 at 7000 ft.; Sikkim, *J. D. Hooker*, *T. Anderson*, etc.

Skimmia Wallichii, *Hook. f. & Thoms.* MS. in Herb. Kew. *Frutex* humilis vix 30 cm. altus, ad nodos inferos sæpe radicans; ramuli crassi, glabri, carnosi. *Folia* persistentia, carnosa, siccitate, chartacea, glabra, lanceolata vel oblanceolata, acuta vel acuminata, 6–15 cm. longa, 2·5–4 cm. lata, nervis primariis obsoletis vel si aliquando siccitate visis utrinque 6–8, marginem versus arcuatim junctis; petioli crassi, 5–7 mm. longi. *Flores* albidi, virescentes, dioici, in paniculis subterminalibus 2–4 cm. longis albo-puberulis breve pedunculatis; bracteæ bracteolæque ovatæ, acutæ, 2–3 mm. longæ, puberulæ. *Calycis* lobi 5, ovati, obtusi, puberuli, 2 mm. longi. *Petala* 5, æqualia, oblanceolata, 5 mm. longa. *Stamina* petalis æquilonga, in floribus ♀ minora. *Ovarium* in ♂ minutum, stylis 3 filiformibus, stigmatibus minutis; in ♀ globosum, stylo crasso brevi, stigmate magno capitato lobato. *Fructus* coccineus, globosus, carnosus, circa 6 mm. diametro, pyrenis 1–3, cartilagineis, pendulis.

Nepal; *Wallich* in 1821; Sikkim, at 9000 to 11,000 ft., *J. D. Hooker*, etc.

Observations on the Root-System of *Impatiens Roylei* *, Walp.

By Isabel McClatchie, B.Sc. (Research Scholar in Botany, University College, Nottingham). (Communicated by H. S. Holden, M.Sc., F.L.S.)

(Plates **37**, **38**, and 24 Text-figures.)

[Read 14th December, 1916.]

Introduction.

Impatiens Roylei, Walp., is a hardy annual of Indian origin which, owing to its very efficient seed-dispersal mechanism, spreads rapidly. It is difficult to eradicate, and tends to become a troublesome weed. The plant is common in the Midlands, and occurs in extensive beds in neglected gardens in which it has gained a footing. In these crowded areas the plants rarely reach their full development; the tallest specimens do not exceed one and two-third metres, and the lateral branches are small and lacking in vigour. A well-grown solitary plant may attain a height of three metres, measure six centimetres in diameter at its base, and possess well-developed branches, these being borne in whorls of three or four.

The plant shows for its size a remarkably poorly developed vascular system, the xylem even in large plants forming only a thin ring, so that mechanical efficiency is almost entirely due to the turgid parenchyma. The nodal regions are usually dilated, as are the bases of the lateral branches, so that prominent bulges are produced, these being particularly noticeable in well-developed branches.

Primary Root-System.

The seeds of *Impatiens Roylei* germinate in late April or early May, the seedling being of the normal dicotyledonous type, and having a primary root-system consisting of a tetrarch tap-root and tetrarch or pentarch lateral roots. The hypocotyl varies greatly in length according to the depth at which the seed is buried (Pl. **37**. figs. 1, 2, & 3) and, when it is long, lateral roots of hypocotyledonary origin are sometimes developed; these roots are always subterranean and usually show no regularity in succession and appearance (Pl. **37**. fig. 4). An exceptional case is shown in Pl. **37**. fig. 5, where the roots are in a distinct whorl just below the soil-level.

In the majority of the seedlings examined there is an abrupt narrowing of the axis at the junction of hypocotyl and tap-root, and at this point the tap-root, which is always relatively short, bears a whorl of four strong lateral roots of equal or greater length than itself (Pl. **37**. fig. 5). In other seedlings,

* I am indebted to Dr. O. Stapf, F.R.S., for confirmation of this determination.

constituting a second type, the tap-root tapers gently for some distance below the soil-level, but ultimately narrows suddenly, at the same time giving off a whorl of four lateral roots similar to those referred to above (Pl. **37**. figs. 7 & 8). In a third, and relatively rare type, the tap-root appears to taper gradually to its apex (Pl. **37**. fig. 6). In all cases, however, the root-system remains shallow, and is disproportionately small in comparison with the aerial development of the plant.

Occurrence of Adventitious Roots.

A. *In the young plant.*

When the seedling is about twenty centimetres high and the stem about one centimetre in diameter at its base, the primary root-system is reinforced by secondary roots of an adventitious nature.

These secondary roots first arise near the soil-level and develop from the four xylem poles. Those subsequently formed appear among the primary

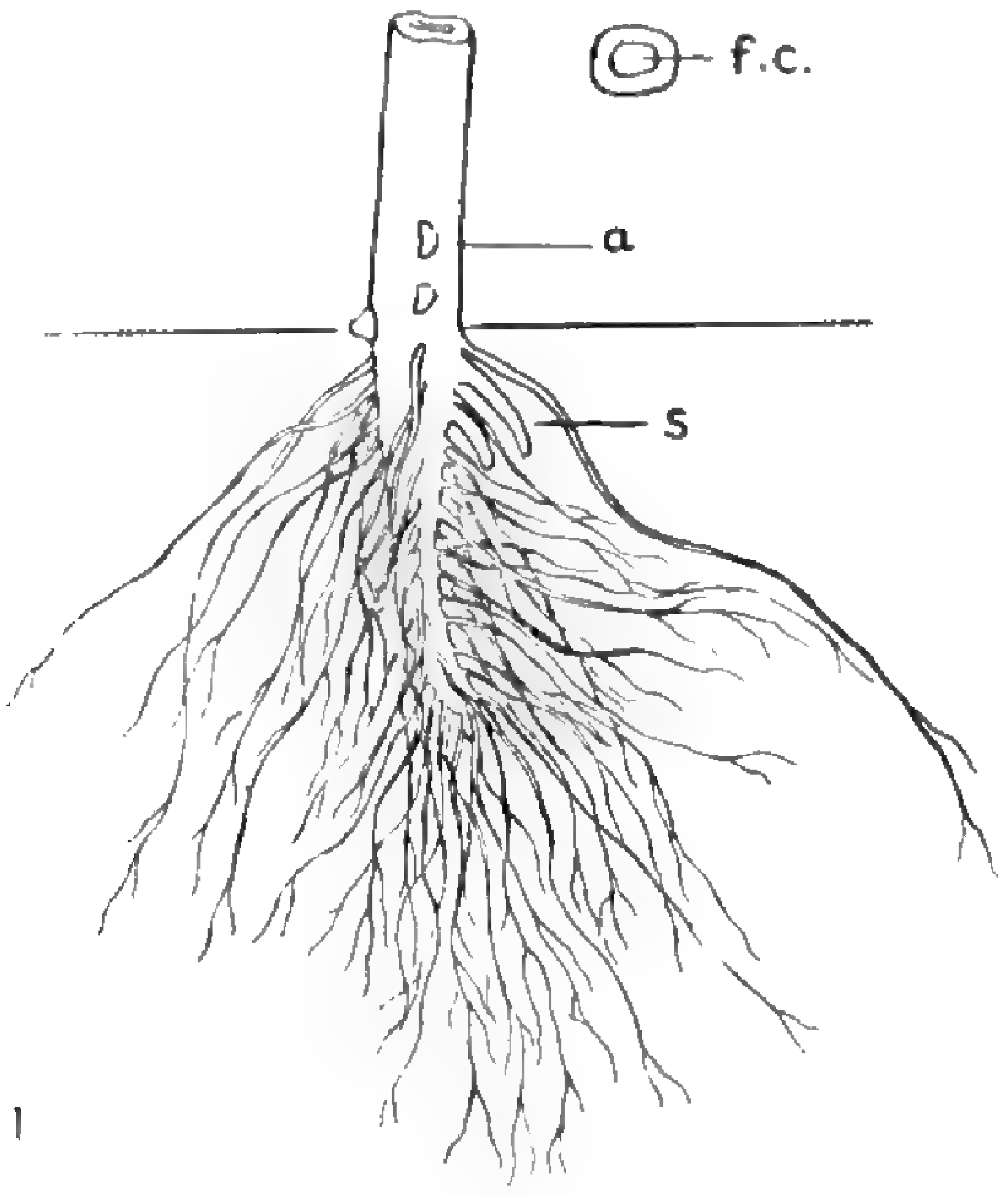

Fig. 1.—Root-system of a young plant showing primary roots and the first adventitious roots. *f.c.*, fistular cavity; *s*, subterranean adventitious root; *a*, aerial adventitious root.

lateral roots, still keeping to the xylem poles and showing a regular acropetal development. About this stage the seedling develops a fistular cavity, the hypocotyl thickens and appears slightly shorter, and simultaneously the first aerial * adventitious roots appear. A few such roots may develop before secondary thickening takes place in the hypocotyl; these necessarily follow the four lines of subterranean roots (text-fig. 1). After this, however, the roots show no regularity in appearance or arrangement; they may arise at

* The term "aerial root" is used in this paper to define roots produced above the soil-level.

the ground-level between the four roots already there, or they may occur at any point slightly higher on the hypocotyl. The subterranean adventitious roots show a like freedom in development.

Both aerial and subterranean adventitious roots are much stouter than the primary laterals, and they characteristically possess a bluntly rounded apex when they emerge from the stem. The aerial ones develop a red epidermal pigment, similar to that occurring in the epidermis of the stem, and they sometimes show a rather sudden decrease in diameter about two-thirds of the way from the base to the tip (text-fig. 18 *b*). Round the base of each root is a projecting rim formed by the tissue of the axis (text-fig. 2).

B. *On the main axis of upright plants.*

In perfectly upright uninjured plants many adventitious roots arise near the ground-level; they develop lateral roots freely upon entering the soil and grow to a considerable length, thus forming a large accessory root-system, but they rarely occur in any numbers at higher points on the hypocotyl, and in only one case have they been found to appear on the main axis above the first (*i. e.*, the cotyledonary) node. In this exceptional case (text-fig. 3) four stout roots grew out at the base of the first epicotyledonary internode, and were nearly equally spaced round the stem, but in spite of their early promise they soon ceased growing and never reached the soil. In this respect they resembled the solitary adventitious roots on the upper portion of the hypocotyl.

C. *On lateral branches.*

Although it is exceptional in upright plants for adventitious roots to develop normally on the main axis above the first node, they are produced in large numbers from the lower side of the swollen bases of the robust lateral branches (text-fig. 4 *a*). In the largest plants (height two to three metres) they occur as high as the fourth branch whorl from the base, but the roots decrease in frequency from below upwards, and are never produced from feeble branches. The swollen base of one branch may bear as many as ten roots, and in all cases the roots, where at all numerous, are closely crowded. It is in these roots that the typical narrowing, one-third distant from the tip, is most frequently shown. No roots developed from lateral branches exceed a length of three or four centimetres, and they are, therefore, normally abortive.

D. *In plants bent at the nodes.*

In large beds of closely crowded plants upright specimens are exceptional. Not only do the weakly and injured plants trail for some distance along the ground, but those that are comparatively well developed, with a height of one and two-third metres, and a basal diameter of two to three centimetres, show a bend at the first node, so that the hypocotyl makes an acute angle

with the ground. This angle varies in size, so that the hypocotyl may occupy any position between the vertical and the horizontal.

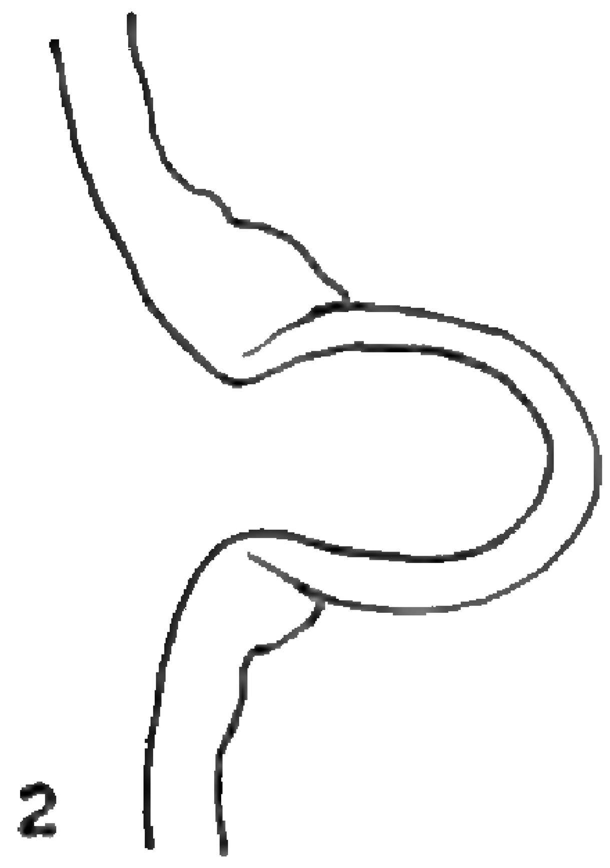

Fig. 2.—Longitudinal section of a young adventitious root emerging from the stem. At the base of the root is a rim formed by the ruptured cortex.

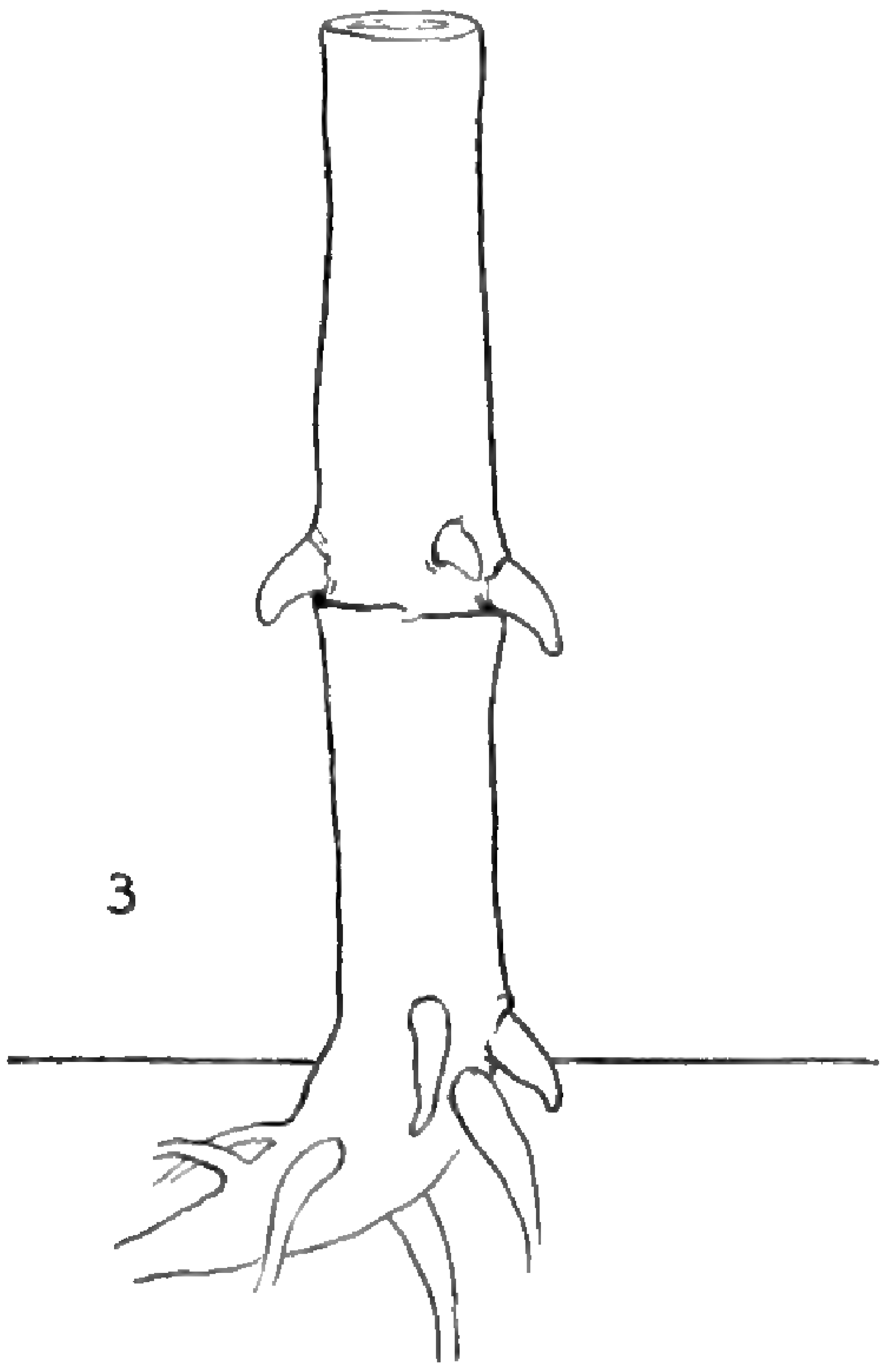

Fig. 3.—Upright plant showing adventitious roots near the ground level and the unusual development of roots from the base of the first epicotyledonary internode.

Fig. 4 *a*.—Adventitious roots developing from the lower side of the swollen base of a robust lateral branch. Note the typical change in the diameter about one-third distant from the tip.

One large group of plants which grew on the north side of a high wall running almost due east to west, and which consequently never received the

direct rays of the sun owing to the shade cast by the wall, exhibited this feature markedly. The bending in all cases was away from the wall and towards an open space; it was also most marked where the shade was greatest and the plants most crowded and least robust. The pronounced bending appeared, therefore, to be due to a combination of two factors, one of mechanical inefficiency, and the second of light stimulus; the latter largely determined the direction of the bending.

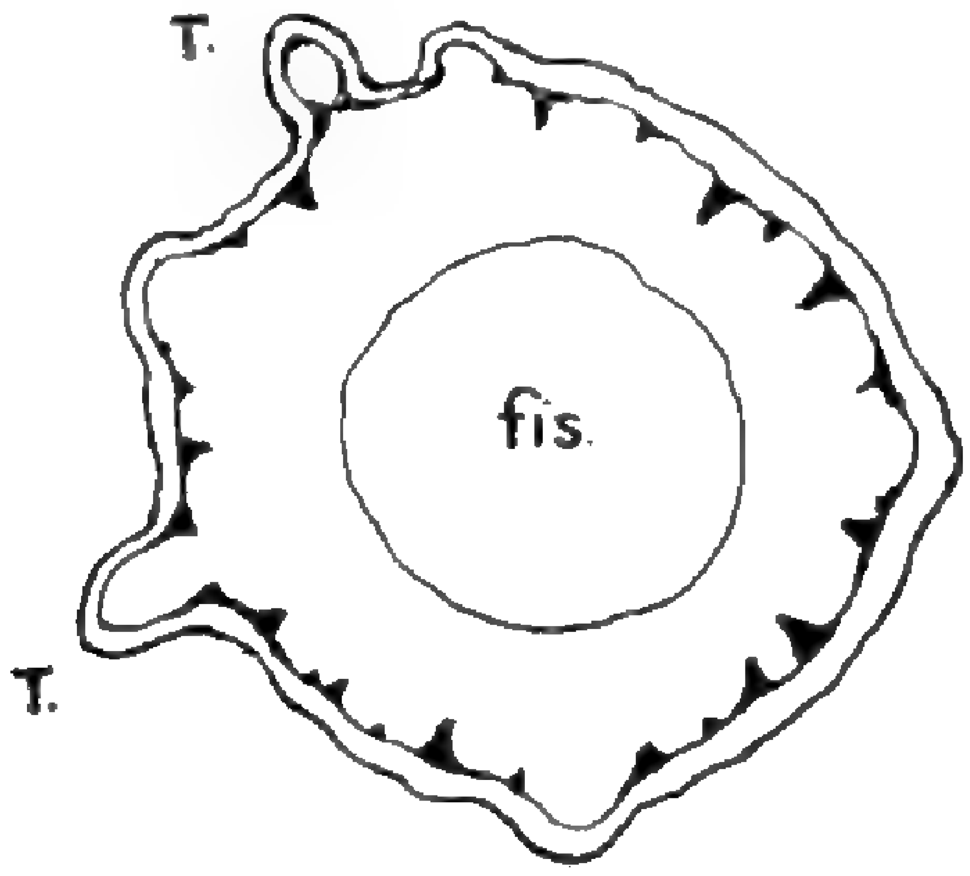

FIG. 4 *b*.—Diagram of transverse section of stem to show relationship of tissues. The xylem is represented as black areas, the phloem as a thin line. T., adventitious roots; *fis.*, fistular cavity.

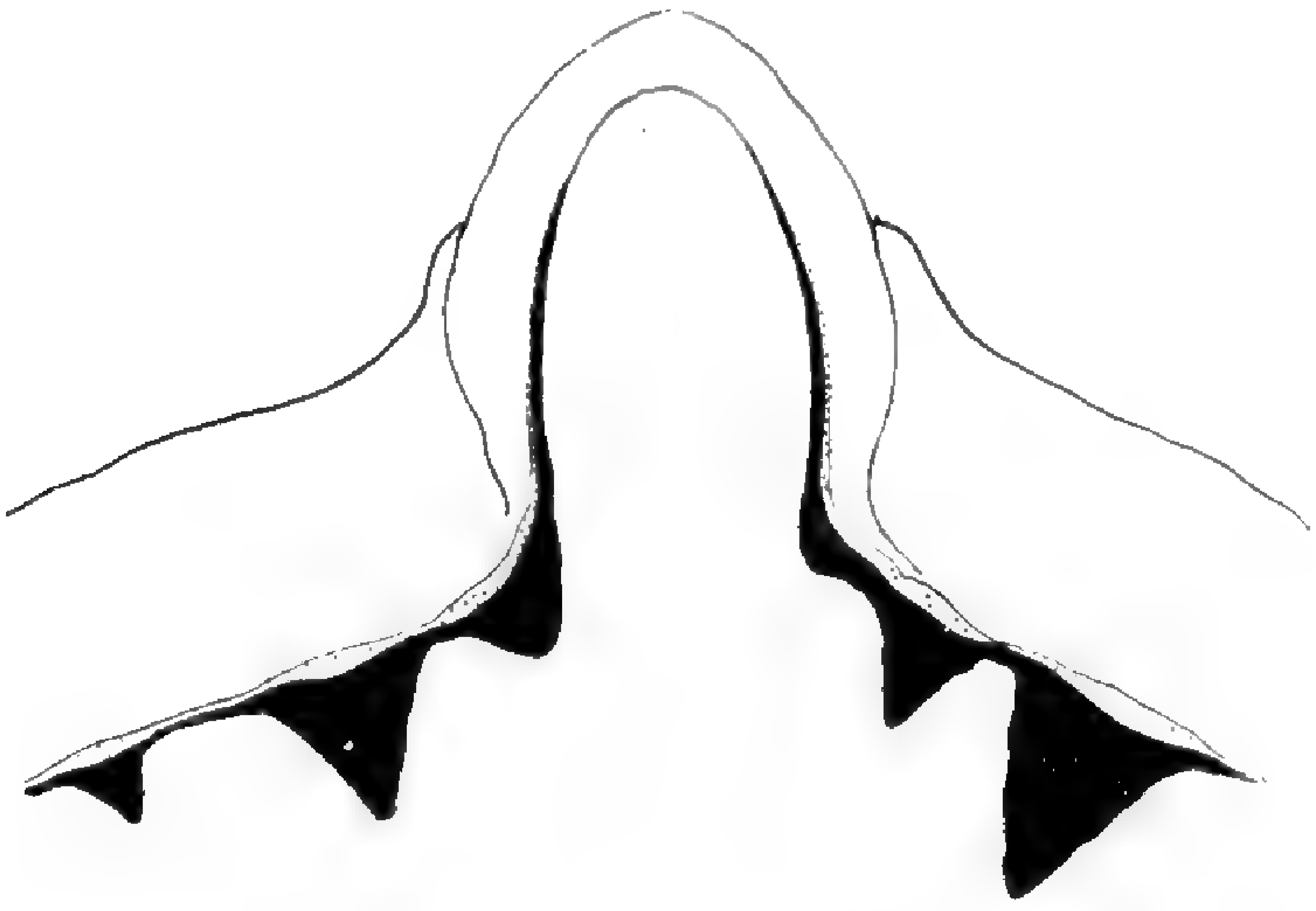

FIG. 4 *c*.—A portion of 4 *b* enlarged to show detail; phloem dotted.

When an inclination takes place, adventitious roots develop immediately above the cotyledonary node on the side nearer the ground (Pl. **38**. fig. 9). One or two may develop just below the node, but this is exceptional. The roots appear even where the deviation from the vertical is very slight, but when the hypocotyl is long they are generally abortive. In the majority of cases, however, the bending, when it takes place at all, is sufficiently marked for the roots to reach the ground after two or three centimetres growth. Upon entering the soil they produce lateral roots and often attain a considerable length (text-fig. 5). Thus the plant is fastened securely to the

ground at the cotyledonary node. A few roots may arise along the underside of the hypocotyl, but they appear after the nodal roots, and they show no regularity in their order of development (text-fig. 6). Adventitious roots never arise normally on that side of the axis which makes an obtuse angle with the ground, however little over 90° that angle may be.

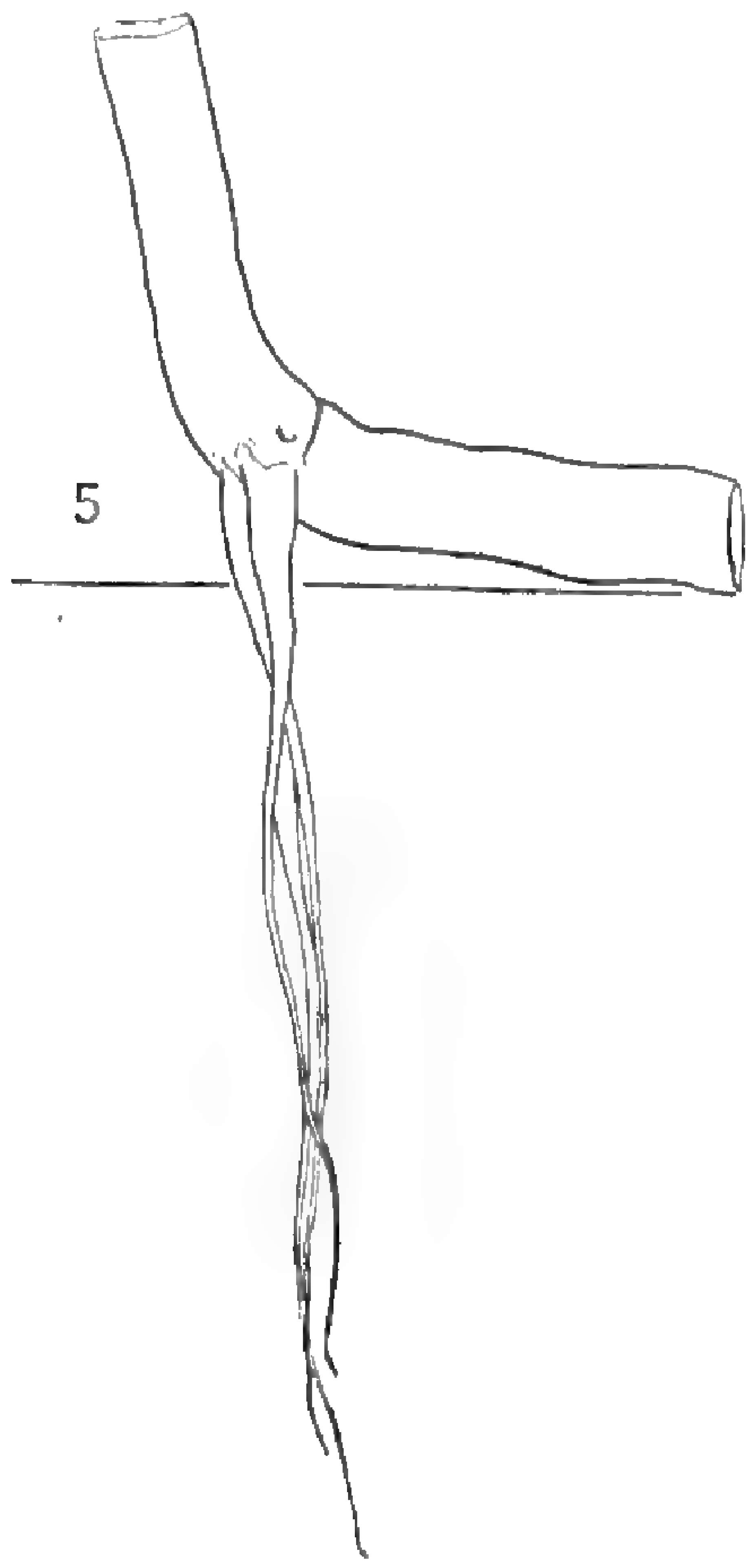

Fig. 5.—Plant with hypocotyl nearly horizontal; adventitious roots have anchored the plant to the soil at the first node.

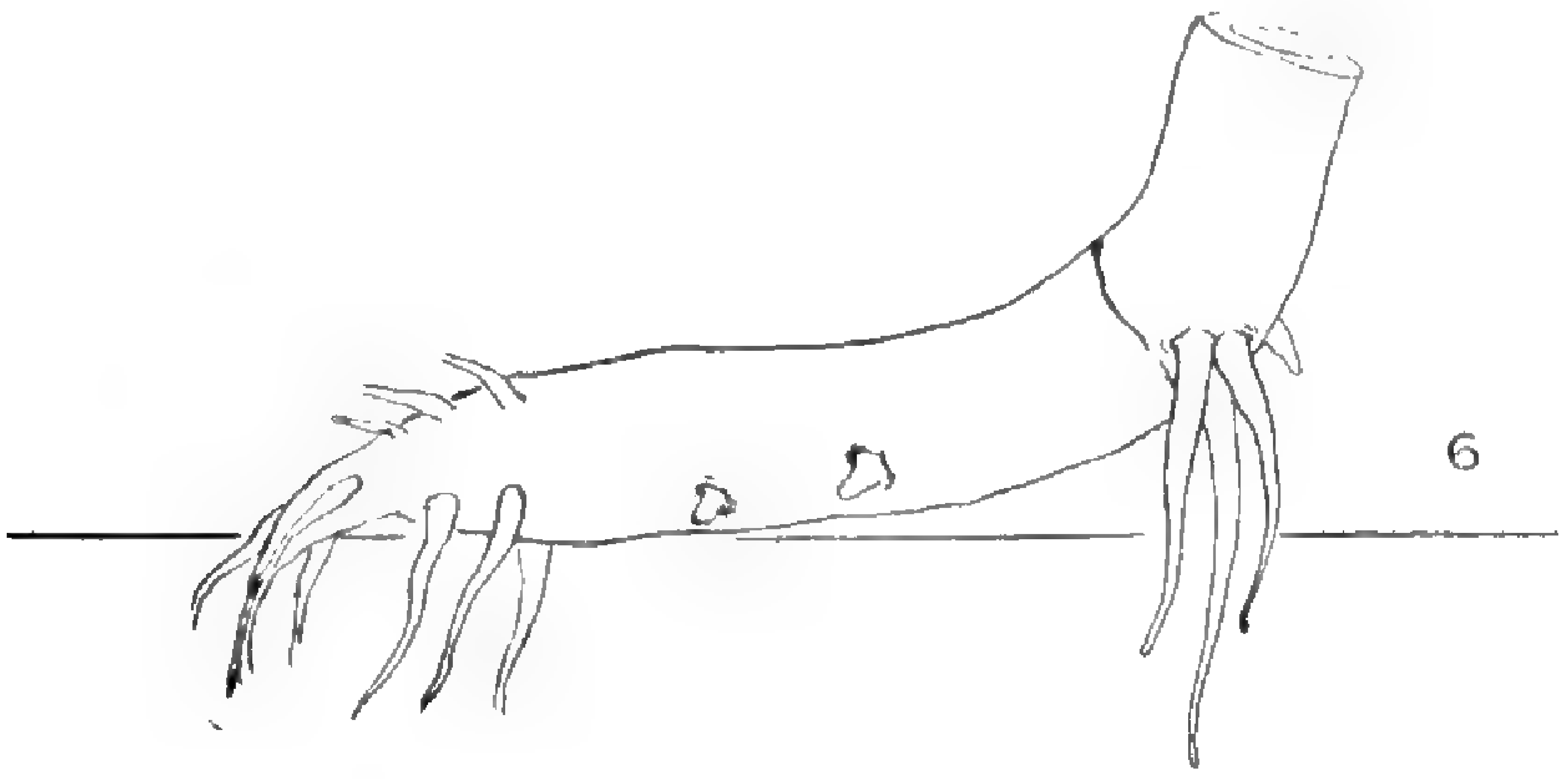

Fig. 6.—Plant showing roots developing from the underside of the hypocotyl.

In the most crowded areas in the bed of plants referred to above, particularly at the base of the wall where the shade was greatest, the plants were not only bent at the first node, but at the second, and in some cases the

third node also. Consequently, the stem had a jointed appearance for the first four internodes, and then it regained its vertical position. Traces of adventitious roots appeared above many of these bent nodes, but the roots rarely emerged from the stem ; at the best they were slender and short (text-fig. 7).

There are always some weak straggling specimens, small and incapable of self-support. These trail along the ground for two or three internodes, producing roots from the hypocotyl and from the under surface at the first and second nodes, and also in rare instances from the first epicotyledonary internode. In these beds of plants it is very exceptional to find roots developed from the lateral branches, since the latter are undersized and feeble.

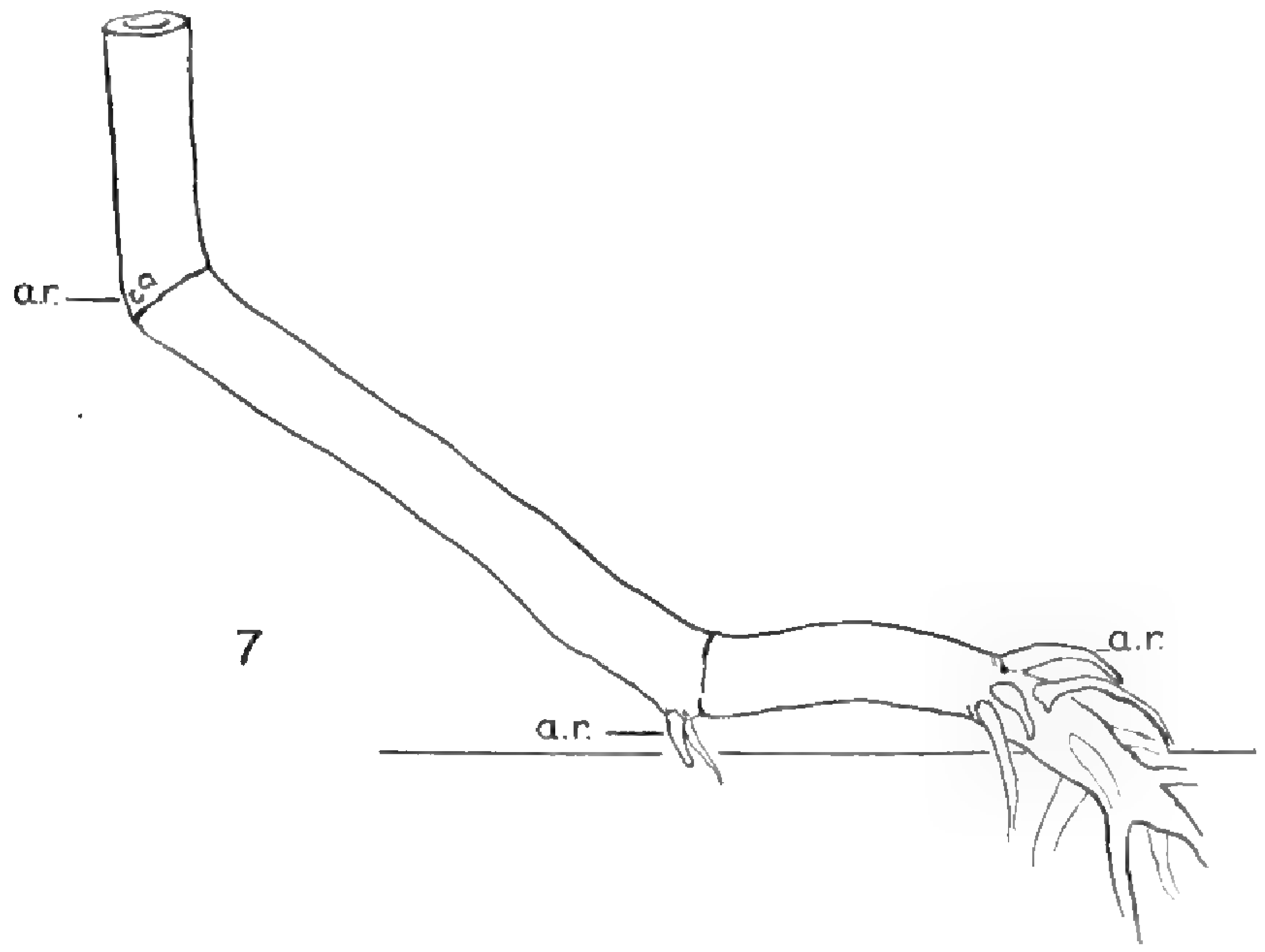

Fig. 7.—Plant bent at first and second nodes. *a.r.*, adventitious roots.

E. *In plants with slit internodes.*

Passing now from perfectly whole plants, whether upright or bent, we come to plants which show a longitudinal slitting of the internode. This feature is of common occurrence in the species, and may be due either to the disturbance of the osmotic tissue tensions caused by the formation of a fistular cavity, or by mechanical injury. An internode may show from one to four slits extending down the greater part of its length. The hypocotyl and the first and second internodes are most frequently affected.

Adventitious roots sometimes develop at the node just above the slit region on the side of the greatest disturbance, even though the stem is vertical (text-fig. 8). They arise, as is the case in bent plants, just above the node, but they never attain a great length (the maximum length noted was half a centimetre).

Their development, both in these cases and in those of the wounded plants described below, seems to be an abortive attempt to compensate for the interference with the water-supply, and with the translocation of elaborated food. It is possible, too, that the nodal bending of the plants in which adventitious roots are developed may also cause such compression of the food-channels as to induce accessory root-formation, although, in view of the relatively slight amount of bending in many cases, this is distinctly problematical. The cases described by Detmer * of root-development in willow shoots in which partial ringing has been practised, and in shoots of *Nerium Oleander* and *Mirabilis Jalapa*, which possess accessory medullary bundles, seem to offer a partial

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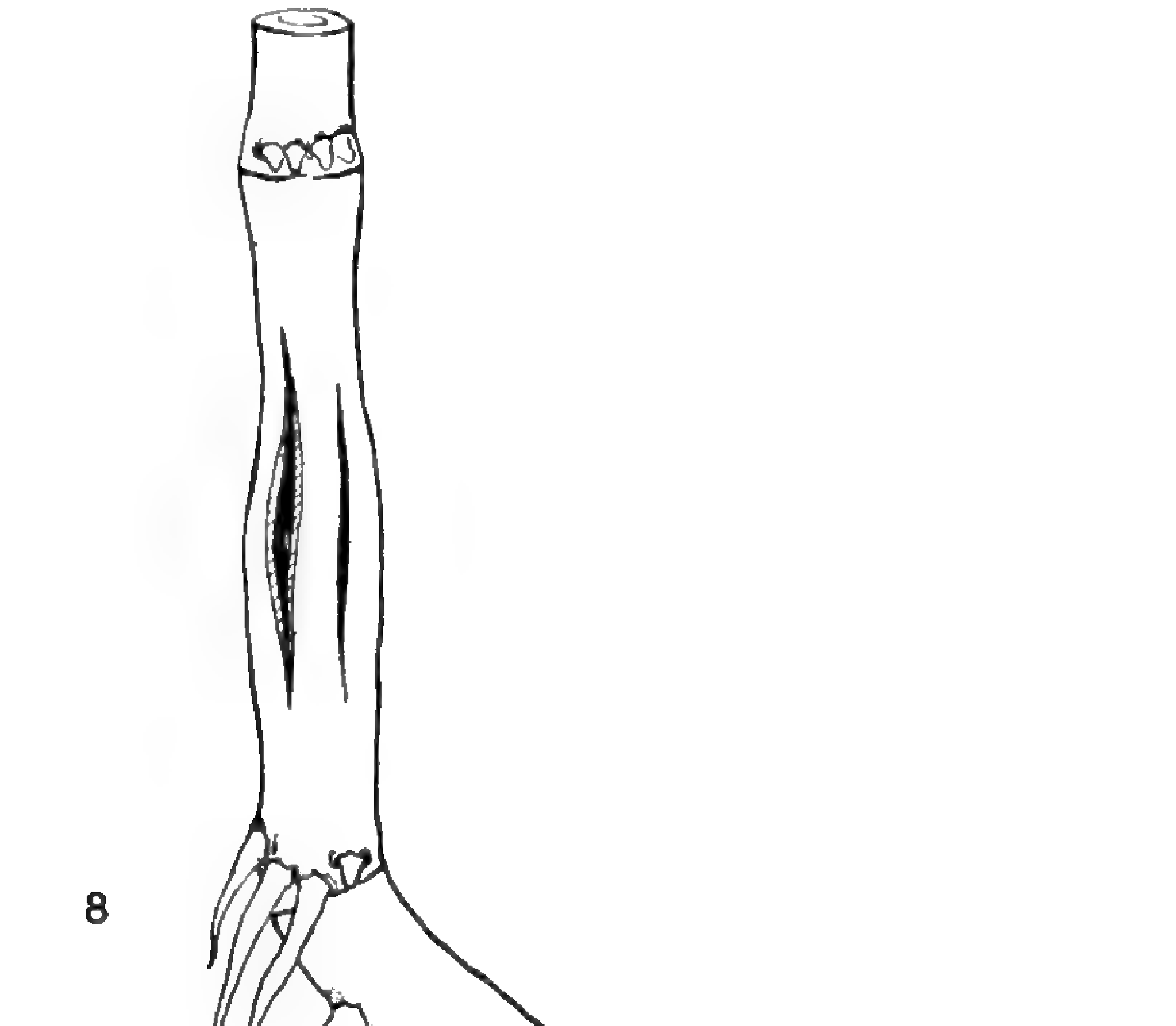

FIG. 8.—Plant showing characteristic slitting of the internode. Adventitious roots have developed from an *upright* stem at the base of the succeeding internode.

parallel at least to the conditions indicated as obtaining in *Impatiens Roylei*, although the object of the experiments upon these plants is to demonstrate the stimulus to root-formation *below* the seat of injury, provided that sufficient tissue is provided for the translocation of proteid material.

F. *In wounded plants.*

Many plants are found which have suffered some accidental injury, and it is interesting to note the resulting root-development in these cases also.

* W. Detmer, 'Practical Plant Physiology,' trans. by S. A. Moor (1898), Third Section, pp. 351–3.

Text-figure 10 shows a plant which was almost severed from its root by a wound at the base of the hypocotyl. Only a small portion at "*a*" remained in connection with the basal root-system. A large number of small tooth-like adventitious roots developed just above the wound, not only from the under surface, but from the upper and side regions also. The roots assumed a curved form as they began to grow round the stem to reach the soil. Unfortunately the plant died before these roots had reached the ground, and it was therefore impossible to tell whether or no it would have received an adequate water-supply from them if they had had time to develop further.

The type of wounding shown in text-figure 9 was also commonly found. In the plant represented, the stem was deeply cut a little above the

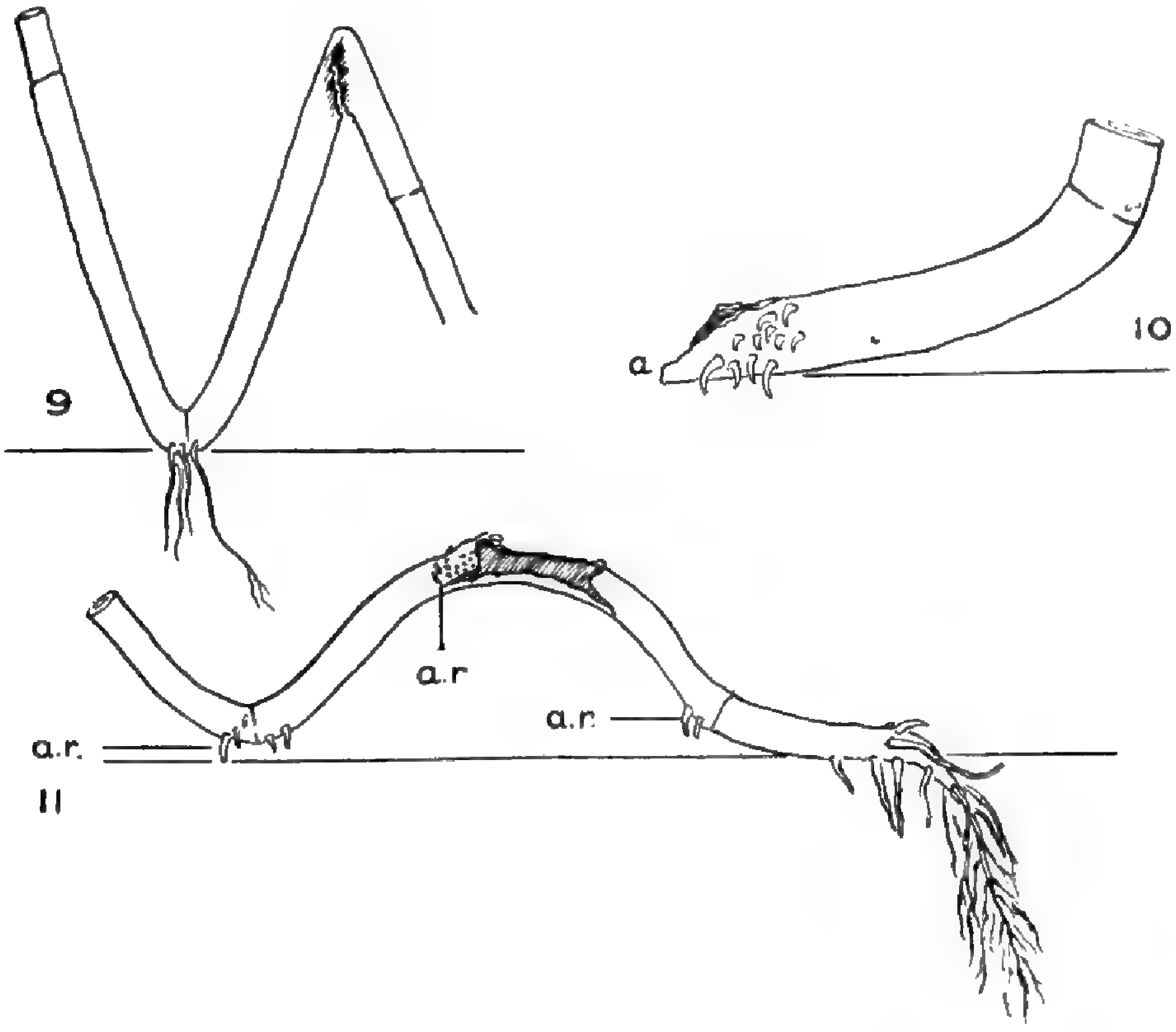

FIG. 9.—Plant showing severe wound in the first epicotyledonary internode.

FIG. 10.—Plant wounded at the base of the hypocotyl; only a small portion at *a* remained in connection with the root-system.

FIG. 11.—Plant showing extensive but shallow wound. Adventitious roots have developed from the *upper* side of the stem above the tear. *a.r.*, adventitious roots.

second node, and the weight of the plant gradually pulled the stem over at that point with the wound in the acute angle of the bend. The stem adjusted itself in such a way that the third node touched the ground and supported the upper portion of the plant, which assumed an approximately vertical position. Adventitious roots developed at this node, both above and below it, from the convex side; they entered the soil and produced lateral roots. Thus they both anchored the plant to the ground and reinforced the water-supply.

Text-figure 11 shows another injured plant where the wound, though greater in area, was rather less extensive in a transverse direction, and the stem took a curved position with the tear on the upper surface. The second node fell to the ground and roots developed both above and below it on the convex side. In addition to this, minute roots appeared on the upper surface of the stem above the wound. This appeared to be another abortive attempt to reinforce the food-supply, and here, too, as in the previous case (text-fig. 10), the roots arose above the wound, even though it was on the side of the stem furthest removed from the soil.

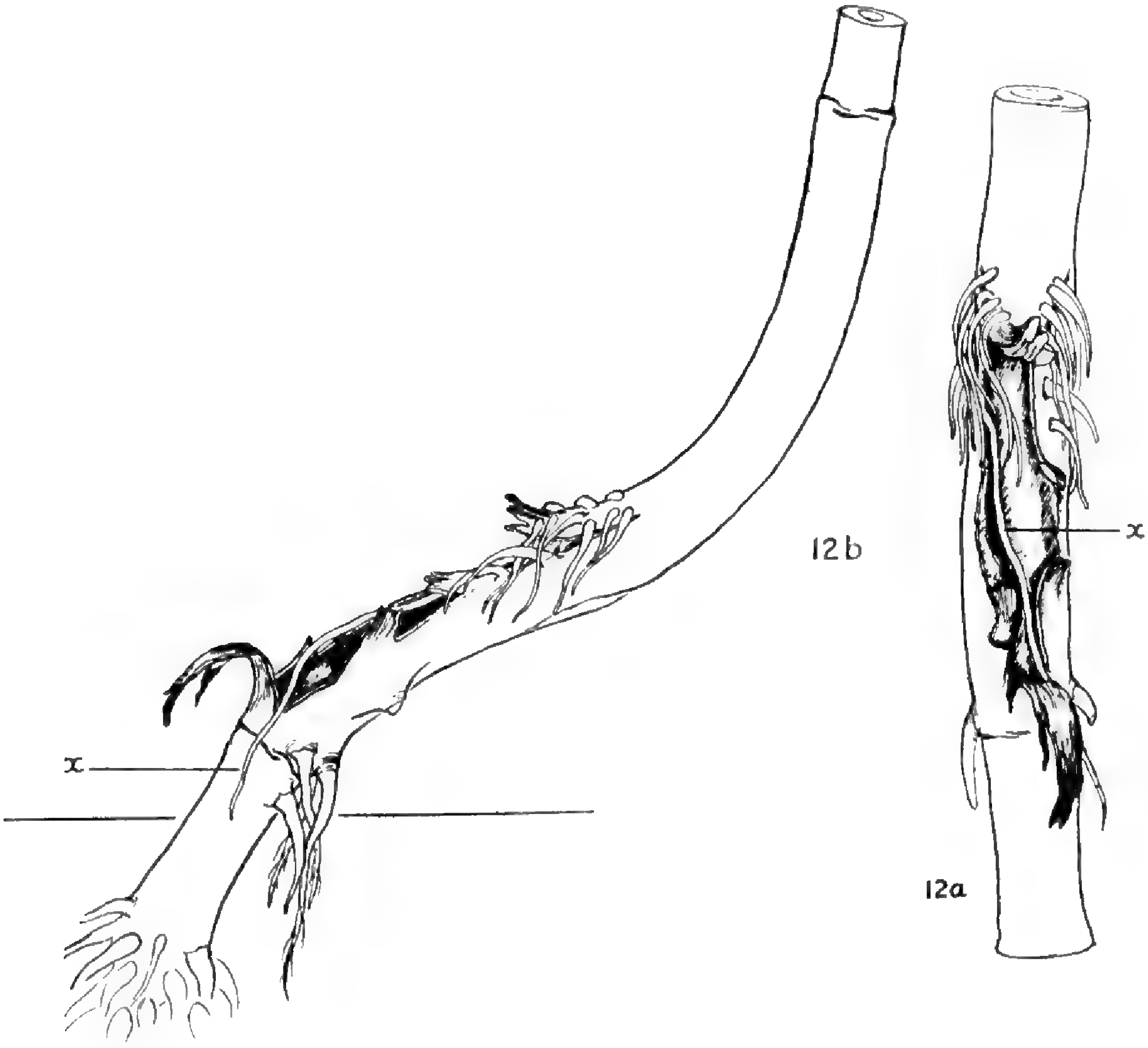

FIG. 12 *a*.—Plant with an extensive wound in the lower half of the supercotyledonary internode, and showing a profuse development of roots from the upper surface of the stem.

FIG. 12 *b*.—Side view of the same wound. Root x attained a length of eleven centimetres and so reached the soil-level.

In text-figs. 12 *a* and *b* are shown respectively the front and side views of a very extensive wound. In this plant there was a tear of about six centimetres in the bottom half of the first epicotyledonary internode, but the

stem, except for a curvature in the wound-region and a counter curvature in the upper half of the internode, maintained its vertical position. This injury was most probably inflicted during digging, and the plant became buried rather obliquely, almost to the cotyledonary node. There was a profuse development of adventitious roots.

Above the injury the roots arose, as usual, on the same side as the wound. They developed in large numbers from the upper side of the lip of tissue that projected above the tear, but in growing they took a curved form over the lip and round the stem. As in previous examples, this seemed to be an attempt to compensate for a deficient food-supply ; in this case, however, one root attained a length of nearly eleven centimetres, and so reached the soil-level. Below the wound, at the cotyledonary node on the side inclined towards the ground, the roots already developed penetrated the soil and produced lateral roots, and thus increased the food-supply to the plant.

Experimental Work.

1. Experiments on Seedlings.

Attempts were made to induce root-development in the hypocotyl between the soil-level and the cotyledonary node. Very young seedlings were taken before the appearance of the foliage leaves, and were treated as follows :—

(*a*) The hypocotyl was completely buried in a cone of soil.

(*b*) The hypocotyl was surrounded by soil to a point half-way between the original soil-level and the cotyledons.

(*c*) The hypocotyl was pegged down so that it lay horizontally along the soil.

(*d*) The hypocotyl was pegged down as in (*c*), but it was also buried under a layer of soil.

In all cases the soil was kept moist and the plants left undisturbed until the cotyledons withered.

Results.

(*a*) One seedling only showed roots slightly above the original ground-level, but the roots were indistinguishable in appearance from the primary lateral roots. Their occurrence was not at all abnormal, for, as previously stated, primary lateral roots of hypocotyledonary origin occur in untouched specimens.

(*b*) Negative results.

(*c*) & (*d*) Negative results, but the hypocotyl became swollen and did not elongate.

2. Experiments on Older Plants.

A. *Solitary healthy plants.*

(*a*) *Main axis.*—Ten plants were grown in an open situation and were surrounded, up to their fourth nodes, by a large cone of soil.

Results.

In all cases roots developed all round the hypocotyl. In five cases they occurred in the lower half of the first internode, and in three cases in the upper half also. In two plants they developed throughout the second and third internodes also.

(*b*) *Lateral branches.*—Eight large plants were surrounded by soil to just above their first lateral branches, and these were pegged down to the surrounding soil so that the basal swelling and the first branch-node were below the soil and the second branch-node touched it.

Results.

In all cases many roots developed from the basal swellings of the lateral branches; they grew downwards into the soil, producing many lateral roots.

Five plants showed a number of roots from the first branch-node.

Two plants showed one root at the first branch-node.

One plant showed traces of a single root at the first branch-node.

(*c*) Experiment (*b*) was repeated with higher lateral branches.

Results.

Negative results, except for roots from the basal swellings.

B. *Plants taken from the crowded areas.*

(*a*)—At the end of June a row of ten plants was buried in soil to a height of seventy-five centimetres, so leaving about thirty centimetres exposed. As the plants grew, soil was added, so that the length of the exposed portion remained approximately the same. The soil by which the plants were surrounded was banked up against a wall about four metres high, which ran almost due east to west, and the plants were in a row parallel to the wall and at a distance of half a metre from it. They were left undisturbed until the end of September.

Results.

In all plants there was a profuse adventitious-root development from the main axis. The lateral branches either died or were too feeble to bear roots.

(i.) In all cases roots developed at the first (cotyledonary) and second nodes.
(ii.) In ten cases roots developed at the third nodes.
(iii.) In eight cases roots developed at the fourth nodes.
(iv.) In one case roots developed from the fifth node.

At the cotyledonary node roots were produced, in six plants all round the stem. In one plant there was only a slight root-development on the wall side, and in four plants roots were totally absent on that side. At the higher nodes there was a similar tendency to produce roots only from the side of the plant away from the wall, and the nodes from which the roots were given off were, as a rule, considerably swollen on that side.

There were also many roots developed from the hypocotyl and the first, the second, and (in four cases) the third internode. Where the stem was upright the internodal roots developed only from the side of the stem away

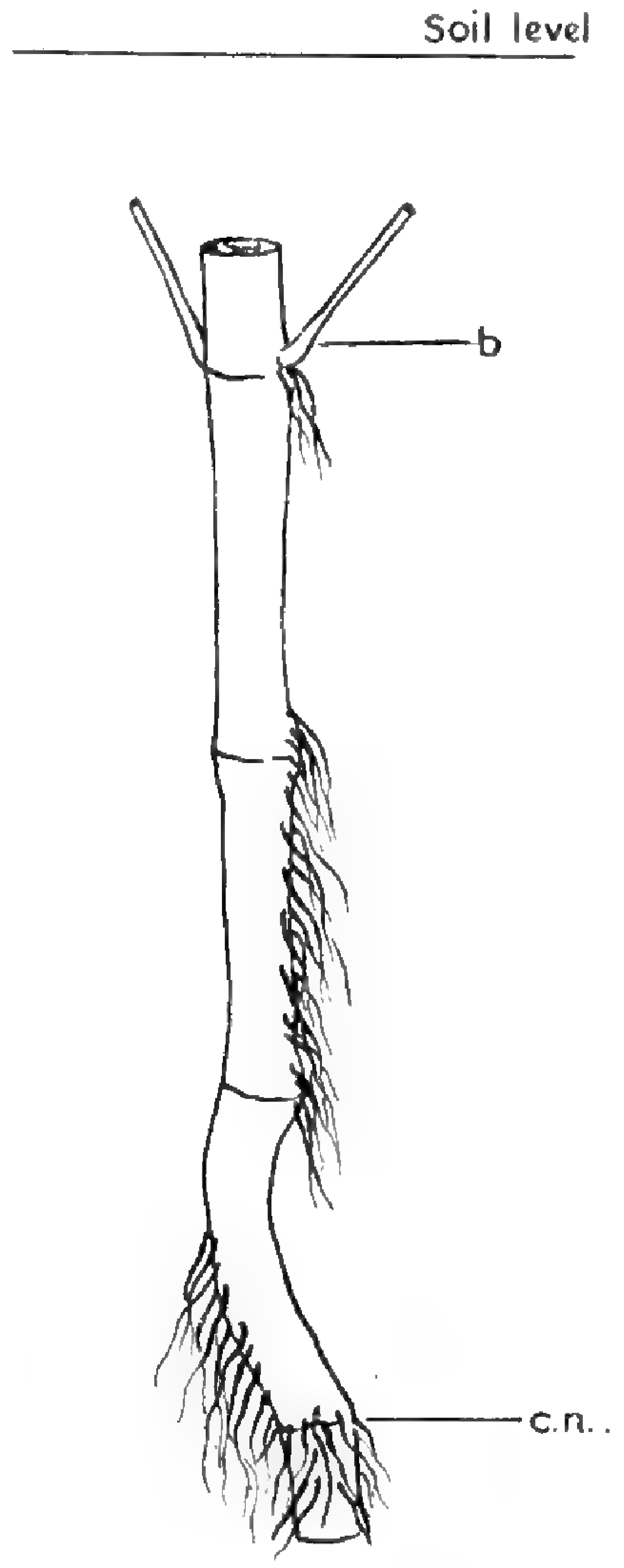

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Fig. 13.—Plant buried approximately vertically in the soil, showing resulting root-development. *c.n.*, cotyledonary node; *b.*, withered branch.

from the wall, but in cases where the stem was bent the roots developed from the convex side only, whatever direction this caused them to take (text-fig. 13).

These roots growing from the internodes did not, as in normal specimens, decrease in number from below upwards. In several instances they were

produced in large numbers down the side of the second internode and yet were absent or of only occasional occurrence in the first internode. In other plants the reverse was the case. One plant produced roots from every node up to the fifth, and yet all the internodes were bare except the third, which was rather bent and had a great number of roots growing from its convex side.

The roots resembled subterranean lateral roots in appearance; they were unpigmented, slender, and produced lateral roots freely. In structure they were polyarch and like aerial adventitious roots, except for the absence of tannin cells.

One very interesting feature was that the roots, though given off from the side away from the wall, did not make a right angle with it, but were in all twelve plants given off towards the north-north-east. This was possibly due to the weight of the soil and the position from which it was thrown during the banking-up process, causing the plants to incline very slightly in that direction.

(*b*)—Six plants were taken about the middle of August and were pegged down so that three or four internodes lay along the soil and the upper surface remained uncovered. They were left in this position until the end of September.

Results.

Where the nodes were in contact with the soil they became swollen, and in five out of the six plants roots developed from the underside. These roots penetrated the soil and produced lateral roots. In four plants there were signs of roots at the bent node, just above the soil-level, where the plant regained its upright position. No roots were produced along the internodes (text-fig. 14).

(*c*)—Six plants were pegged down horizontally, as in experiment (*b*), at the beginning of July, and the horizontal portion was buried in soil to a depth of several inches. They were left undisturbed until the end of September.

Results.

There was a profuse development of roots, but from the underside only. In some cases roots were confined to the nodes, but in others they appeared throughout the hypocotyl, the first, the second, and the third internodes (text-fig. 15).

(*d*)—A number of plants which had developed roots from the underside at the first node were gradually bent until the plant leaned in the opposite direction.

Result.

Although no adventitious roots were developed on the underside, those which had arisen before the experiment ceased to grow (text-fig. 16 *a*).

Wounding of Plants.

1. *Injury to stem.*

A. Twenty plants were wounded at the beginning of August. A deep cut was made above either the second or the third node; it passed nearly half-way round the stem and penetrated to the central cavity.

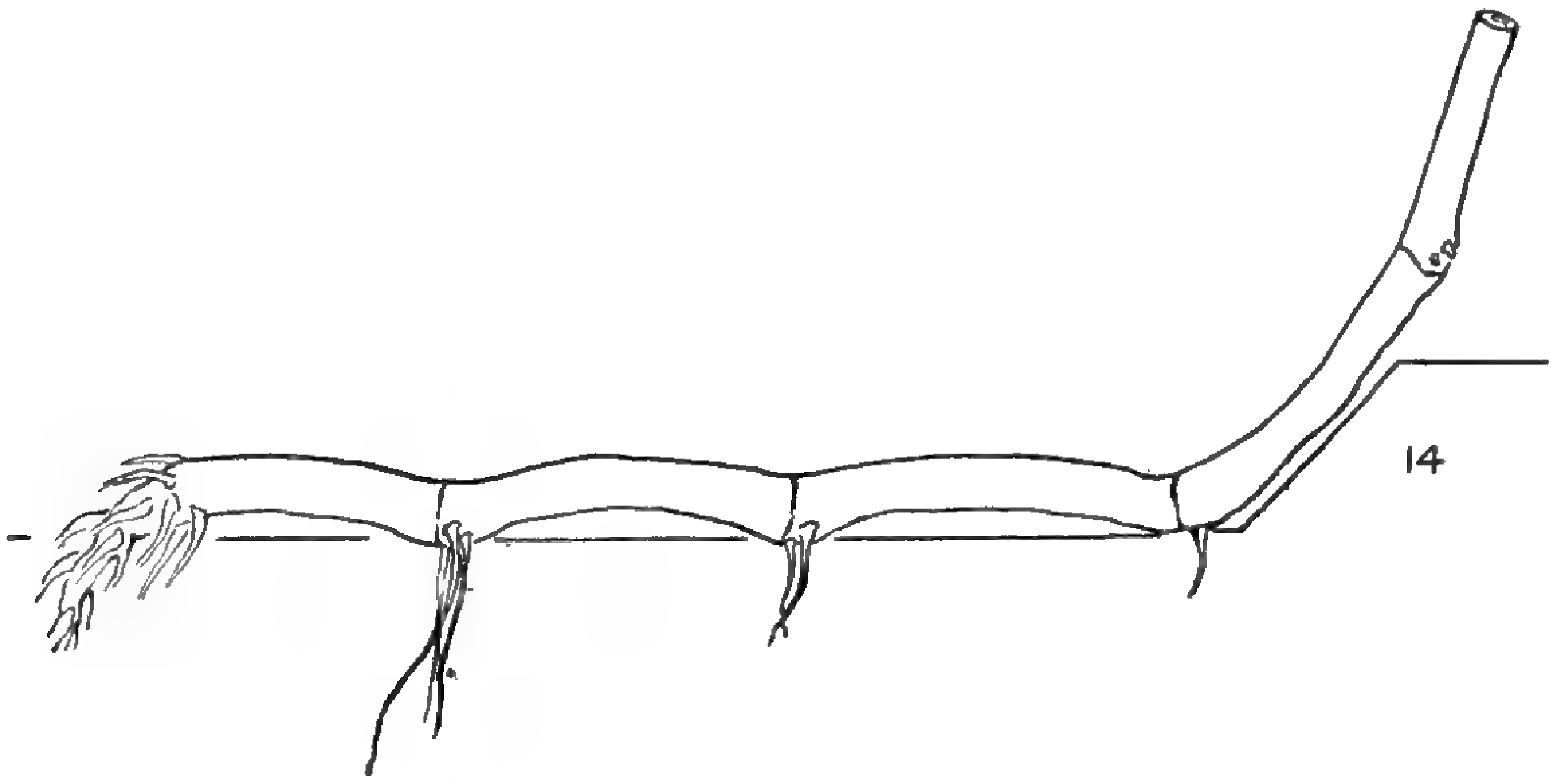


Fig. 14.—Plant pegged down to lie horizontally along the soil.

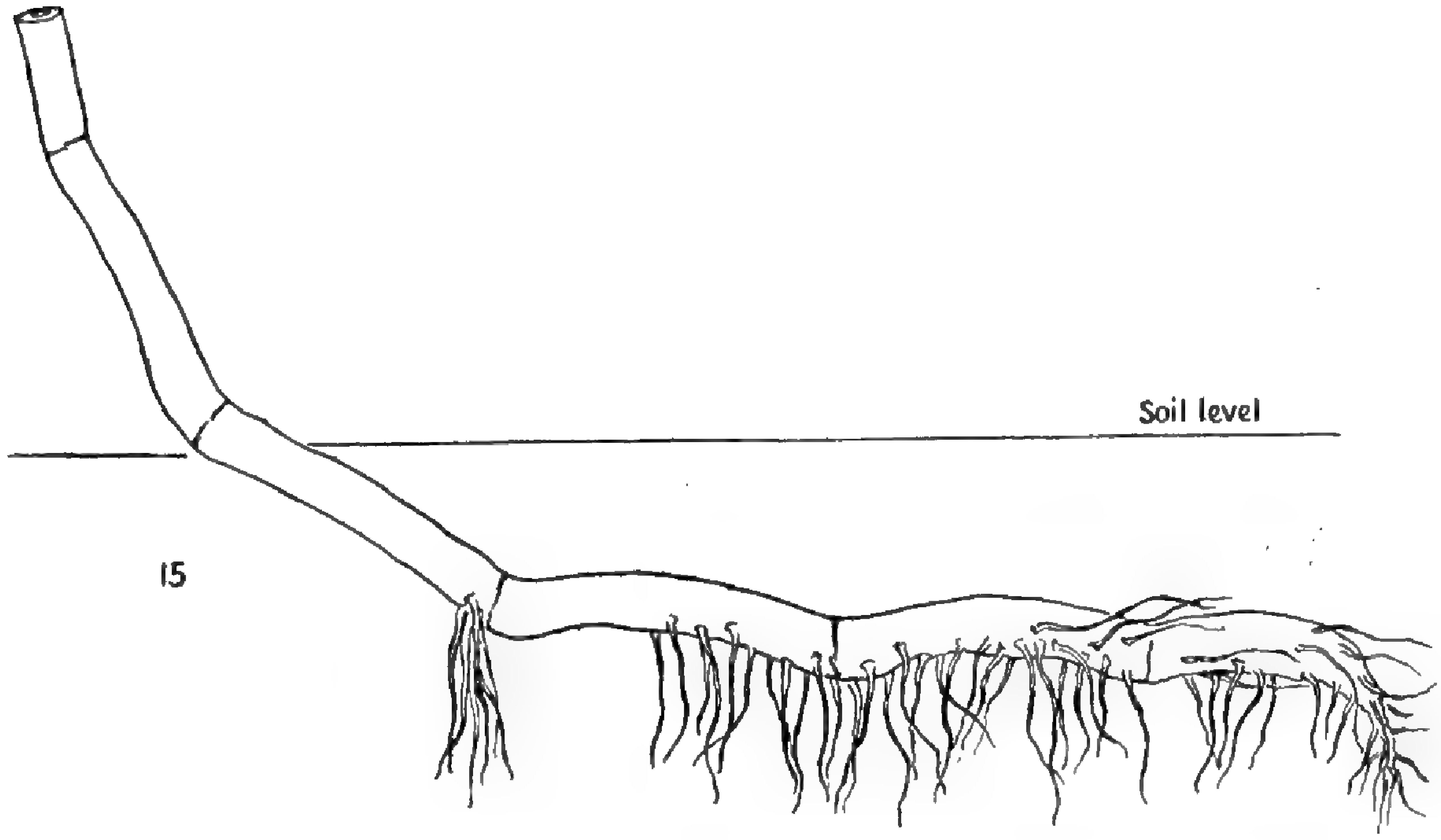


Fig. 15.—Plant buried horizontally under the soil.

(*a*) Ten plants were cut above the second node.
(*b*) ,, ,, ,, ,, third ,,

The plants were tied to a support so that they should remain in an upright position, and were left until the middle of September.

Results.

(*a*)—In four plants there were roots, or signs of roots, just above the cut,

but they were all feeble and never greater than half a centimetre in length. Text-fig. 16 *b* shows the specimen which had the greatest development of roots (the paired arrangement is unusual).

(*b*)—Four plants showed signs of roots, but all were feeble.

In these experiments the roots were always much less numerous and generally smaller than in the cases of accidental wounding, previously referred to. This may be attributed to the fact that not only were the wounds less serious but the plants also maintained their vertical position. The latter condition has already been shown to be unfavourable to root-development.

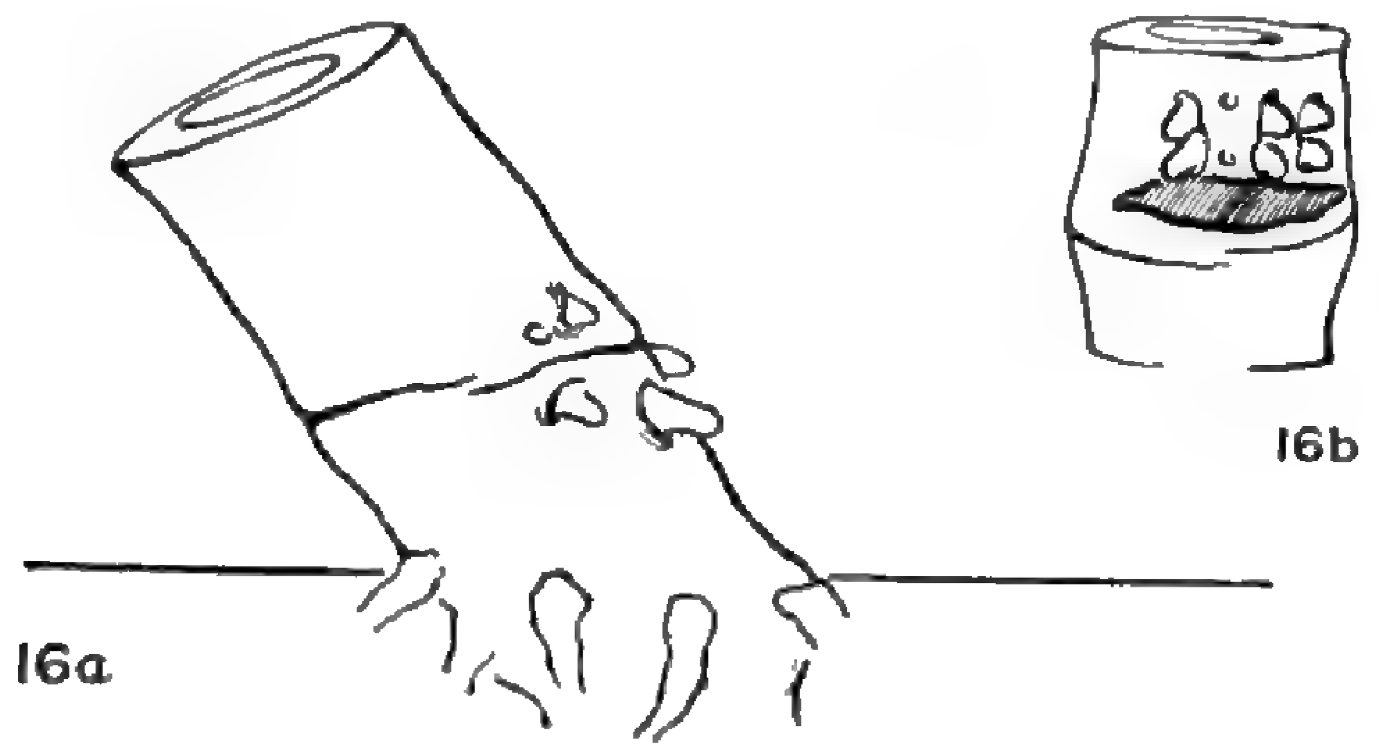


FIG. 16 *a*.—Plant showing arrested root-development, owing to a change in the direction of bending.

FIG. 16 *b*.—Stem showing a cut made above the second node and the resulting development of roots.

B. Twenty plants were wounded below the nodes; the wounds were identical in character with those made in experiment *A*.

(*a*) Ten plants were wounded below the second node.
(*b*) " " " " third "

Result.

In no case was there any signs of root-development. This result is in keeping with the fact that in healthy plants roots generally appear immediately above and not below the nodes.

C. A nearly mature plant was bent sharply down at a point a little above the second node, and the upper portion of the stem was pegged down to lie horizontally along the soil as far as the fifth node. From the swollen undersides of the nodes in contact with the soil adventitious roots developed in large numbers. They penetrated the soil and produced lateral roots. In the meantime the tissues had died at the bend in the stem, although the stem itself remained unbroken. The horizontal and upper portions of the plant seemed none the worse for being cut off from the primary root-system.

2. *Injury to roots.*

(*a*)—In ten roots the tip was removed.

Result.

A crown of rootlets was developed just behind the injury. In roots showing narrowing towards the tip the ring of rootlets was generally given off at the junction of the broad and narrow portions.

(*b*)—Several roots had a length of one to two centimetres cut off.

Result.

Numerous rootlets developed behind the injury. Text-figs. 17 *a* & *b*

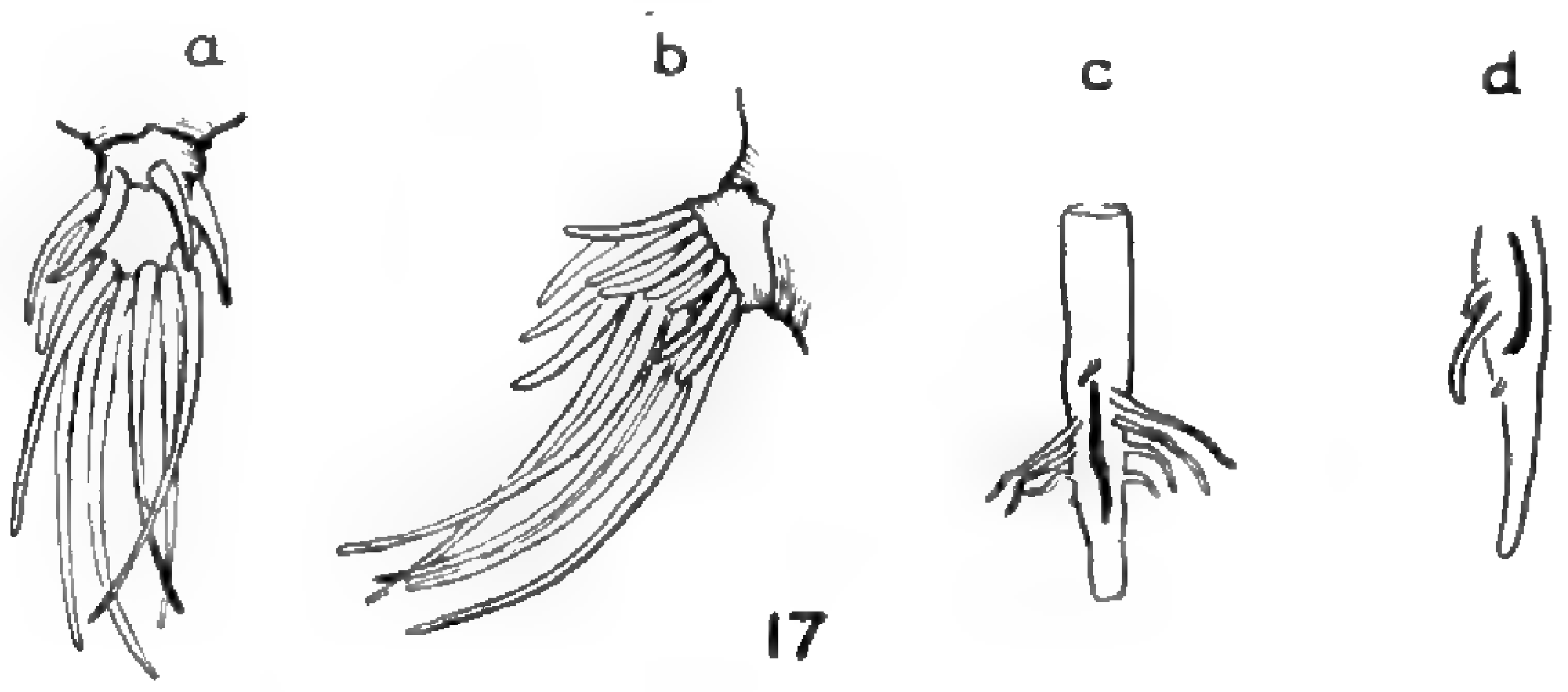


FIG. 17.—*a.* Rootlets developing from an injured adventitious root growing from the swollen base of a lateral branch. *b.* Side view of the same. *c.* Adventitious root with rootlets arising in two rows as the result of a cut made at right angles to the soil (seen from below). *d.* Side view of an injured root with a cut running parallel with the soil.

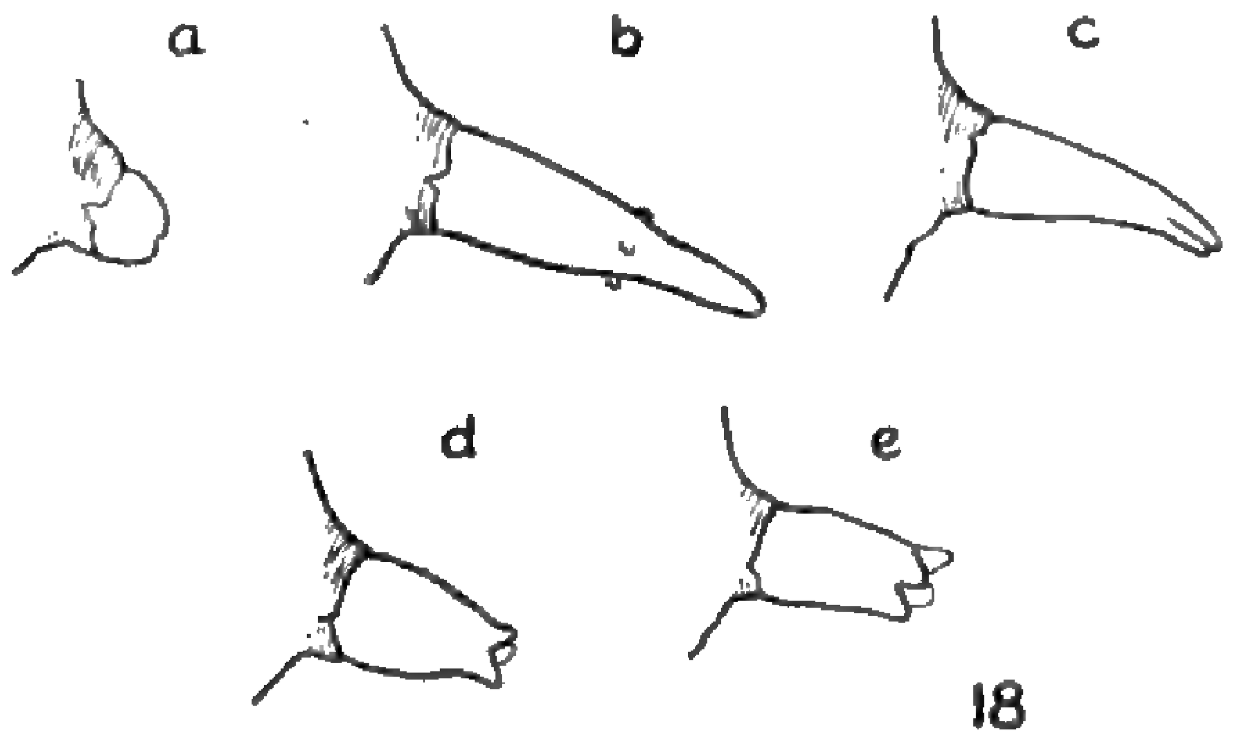


FIG. 18.—*a.* Stunted aerial root with a thick protecting layer of cork. *b.* Root from lateral branch showing typical narrowing and rootlets arising about the junction of the broad and narrow regions. *c.* Root showing apparent dichotomy. *d* & *e.* Roots developing three and four new apices respectively.

show this feature in front and side view respectively. The root was growing from the swollen base of a lateral branch, and was therefore abortive, but the rootlets attained the considerable length of five and a half centimetres.

(*c*)—Roots were slit through longitudinally for a distance of one centimetre.

Result.

Where the slit was at right angles to the soil the rootlets developed in two rows, one down either side and parallel with the soil (text-fig. 17 *c*). Where the slit was parallel with the soil, rootlets appeared on the underside of the root only (text-fig. 17 *d*).

STRUCTURE.

Tap-root.

The tap-root is tetrarch, with xylem to the centre, but rarely develops much secondary wood (Pl. **38**. fig. 10).

Lateral roots.

The lateral roots are generally tetrarch or pentarch, but may be occasionally triarch; they have usually a solid xylem core and develop some secondary wood. In both main and lateral primary roots the vessels become closed by the formation of tyloses, these in the former sometimes being present in quite young seedlings. Both show a considerable amount of cork development. This is produced by the division of the whole of the cortical cells external to the endodermis into series of cambiform elements, which then become suberised. A true pericyclic phellogen is never formed (Pl. **38**. fig. 11).

Adventitious roots.

The adventitious roots are polyarch with eight to fifteen xylem poles arranged round a wide pith. The primary xylem is feeble and secondary thickening takes place very early, but there is never a great quantity of wood present (Pl. **38**. fig. 12). The xylem consists largely of tracheids with annular, spiral, or reticulate thickenings, but the lignification is feeble, and consequently makes staining difficult. The endodermis is well marked, and the cortex regular. Root-hairs are found on the younger portions of the subterranean roots, but they are absent from the normal aerial roots, which develop a subepidermal protecting cork layer at an early stage; this cork is particularly well developed in short stunted roots.

Several plants were found growing in the long grass which bordered the Balsam bed. In these the aerial roots from the cotyledonary node hung down into a moist atmosphere, and during the rainy weather many cases were noted in which the red pigmented roots were covered with a silvery coating of root-hairs for a distance of about two centimetres. In these plants also the aerial roots attained a greater length and remained more slender.

The root-cap is of the commonest type found in dicotyledons, *i. e.*, it is a dermacalyptrogen *.

* Haberlandt, 'Physiological Plant Anatomy.'

Raphid sacs occur in the pith and less frequently in the cortex.

What are most probably tannin cells are very common in the adventitious roots. These cells vary in colour; they may be yellow, light brown to darker brown, reddish brown, or in some cases they have a greyish tinge. They appear in the outer half of the cortex and also in several of the epidermal cells simultaneously with the development of cork. A few isolated cells or pairs of cells of this nature occur in the pith, but these are always less obvious and are of a paler colour. In no cases are these cells found while the root-hairs still persist, and in only very few cases do they appear in young or old subterranean roots. They reach their fullest development in the stout abortive roots, with a considerable quantity of cork, which arise from the lateral branches.

Microchemical tests for tannin were, however, somewhat inconclusive, but the following reactions may be noted:—

1. The cells stained deeply with methylene blue. This test is inconclusive since mucilaginous contents react similarly.
2. In some cases the cells became very slightly darker upon being treated with ferric chloride, but the general results were far from convincing.
3. The potassium dichromate test gave a negative result.
4. The lead acetate test gave a negative result.
5. The ammonium chloride and ammonium molybdate test gave a negative result.

Cells of an identical appearance occur in the pith and cortex of the stem and give the reactions for tannin. This, together with the fact that the cells are almost always absent in subterranean roots, seems to indicate that the aerial roots contain tannin, even though it be but feebly developed, and further support may be adduced from the fact that tannin cells occur in *Impatiens Sultani*, Hook. f.*, so the feature is not exceptional in the genus.

Rootlets from adventitious roots.

An adventitious root upon entering the ground, or as the result of injury, sends out numerous lateral roots. Of these, fifty were examined, with the following results:—

Number of root poles	3	4	5	6	7	8	12
Number of specimens	6	20	14	5	3	1	1

Rootlets are rarely developed except under the two conditions mentioned above, but occasionally traces of them are found in uninjured aerial roots; they then arise about the junction of the broad and narrow regions (text-fig. 18 *b*).

* Solereder, 'Systematic Anatomy of Dicotyledons.'

Their structure is normal, but the relatively early differentiation of the xylem is rather unusual. The root-cap is a dermacalyptrogen, as in the adventitious root itself. In the ruptured cortex there is a fair amount of cork formation and also numerous tannin cells.

"*Branching*" *of adventitious roots and production of rootlets.*

The aerial roots sometimes appear to dichotomise (text-fig. 18 *c*) or to develop three or four apices (text-fig. 18 *d* and *e*). In transverse section

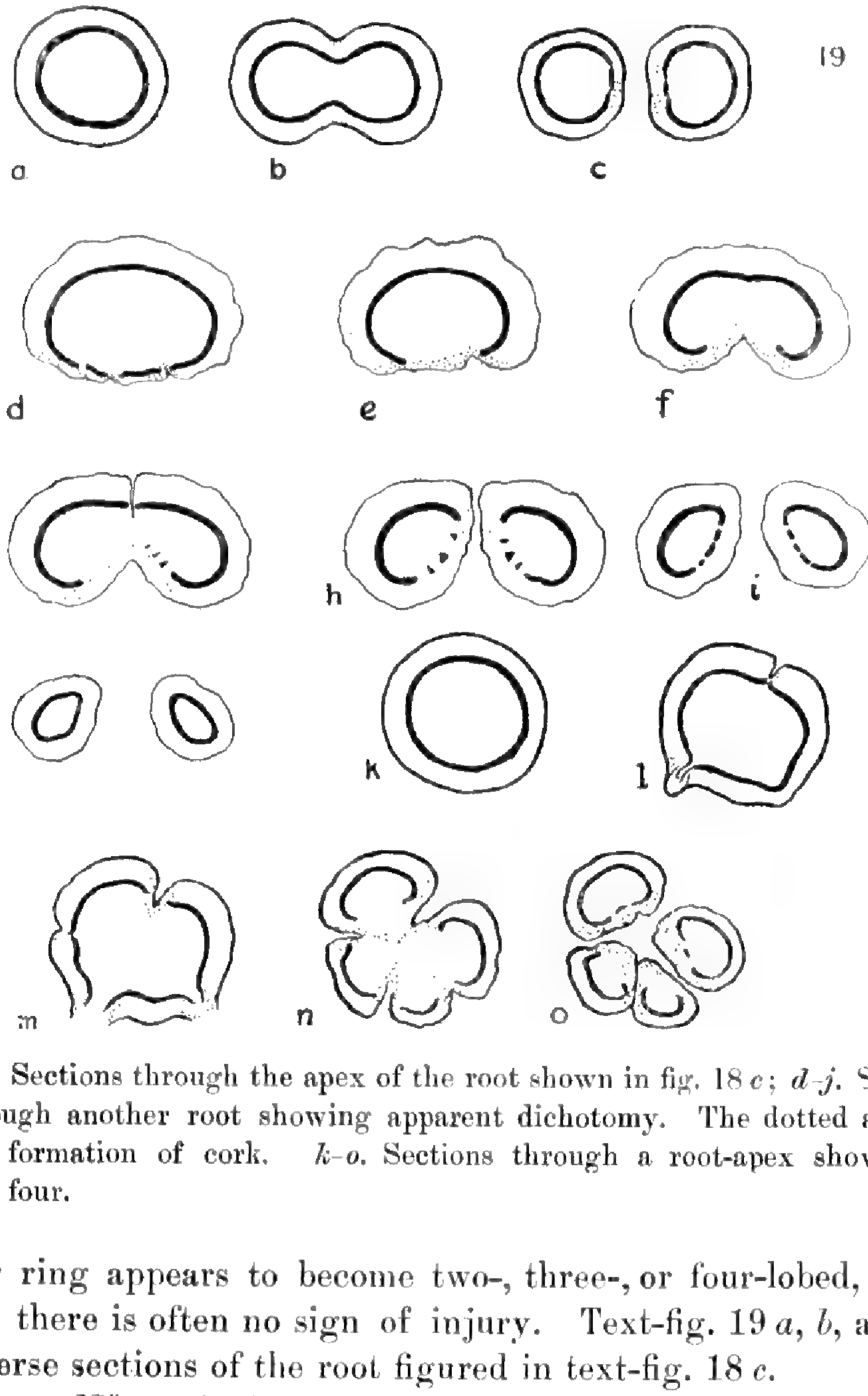


FIG. 19.—*a–c*. Sections through the apex of the root shown in fig. 18 *c*; *d–j*. Serial sections through another root showing apparent dichotomy. The dotted areas indicate the formation of cork. *k–o*. Sections through a root-apex showing division into four.

the vascular ring appears to become two-, three-, or four-lobed, as the case may be, and there is often no sign of injury. Text-fig. 19 *a*, *b*, and *c*, show three transverse sections of the root figured in text-fig. 18 *c*.

According to Němec *, this type of branching in roots is caused by an injury to the root-apex, by which the tip is unevenly decapitated and the torn plerome has an irregular surface with two or more projections. These

* Němec, 'Studien über die Regeneration.'

raised portions may develop into new apices, and the larger the projection, the more likely it is that a fresh apex will result. It is probable that, in the aerial adventitious roots referred to, exposure alone is sufficient to account for the injury to the delicate tissues of the root-tip and thus lead to the characteristic response.

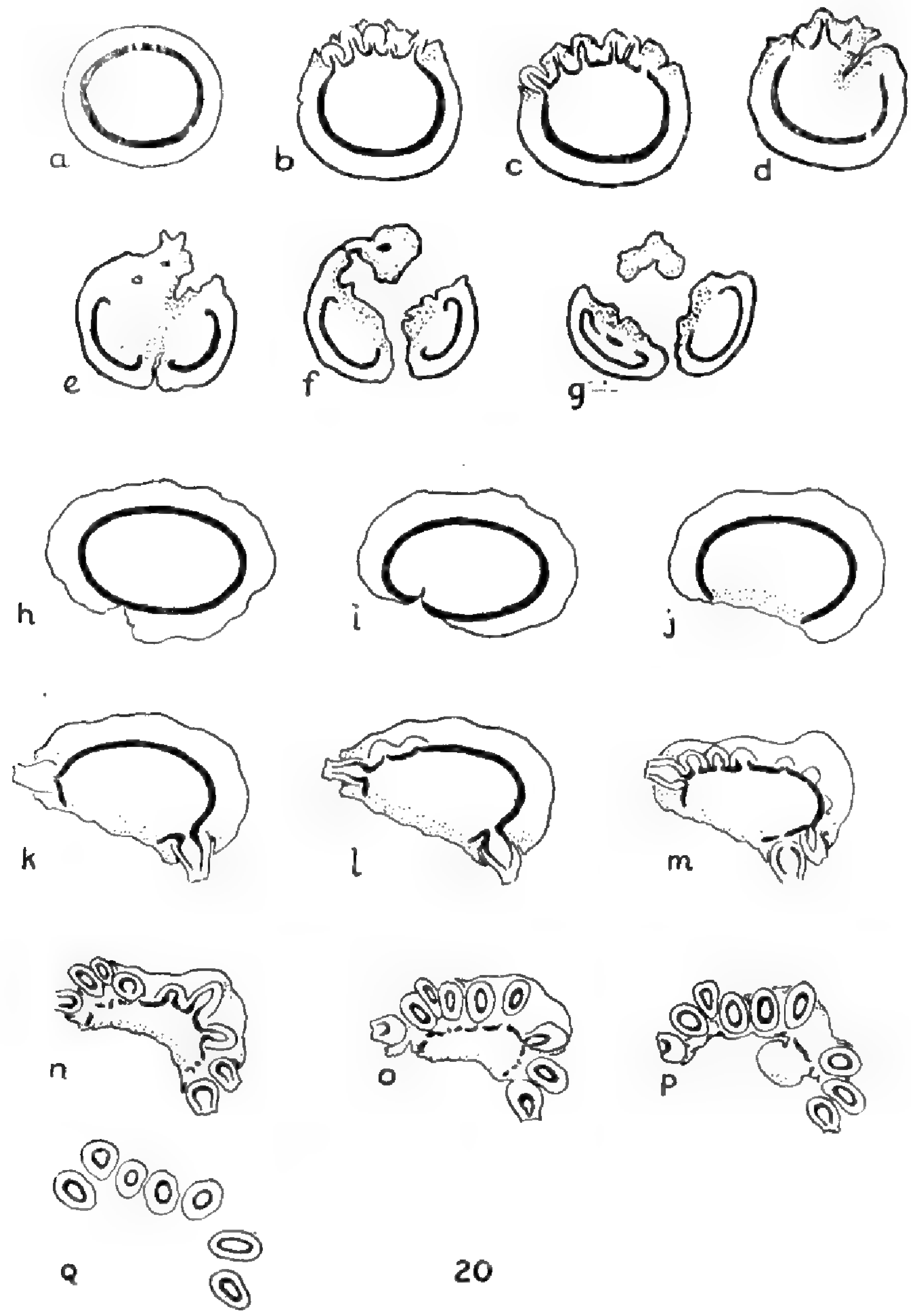


FIG. 20.—*a–g*. Sections through adventitious root showing development of rootlets and of two root-apices as the result of decapitation. *h–q*. Sections through a root showing the development of rootlets resulting from a severe oblique decapitation.

Text-fig. 19 *d–j* show another example of apparent dichotomy, but in this case the injury passed a little way down one side of the root, thus breaking up the vascular ring on that side and causing cork formation.

Text-fig. 19 *k–o* show successive transverse sections of such a specimen as is shown in text-fig. 18 *e*. Here, four projections of the plerome have led to the division of the main root into four. In this case one small rootlet is given

off before division into lobes takes place. In this, as in similar cases, the division into lobes is preceded by the development of cork, which in sections from above downwards seems first to arise in the cortex and to pass inwards to the pith, thus dividing the root into segments.

In text-fig. 20 *a–g* are shown a root in which a number of lateral rootlets are given off just above the wound that removed the apex and slanted towards one side (that from which the rootlets developed). The root itself is divided into three portions corresponding to the three projections of the plerome; two persist and develop root-apices.

In many cases where the injury to the apex is very severe and a considerable portion of the tissues is removed, a number of rootlets develop on the proximal side of the wound. The plerome itself develops no new apices, and the root appears to divide up into numerous rootlets. Text-fig. 20 *h–q* show this type of wound reaction resulting from a severe oblique decapitation.

Summary.

The primary root-system of *Impatiens Roylei*, Walp., is of the normal dicotyledonous type, consisting of tap-root and lateral roots. This root-system remains shallow, and begins to be reinforced by a secondary root-system of an adventitious nature when the seedlings are about twenty centimetres high and have initiated a fistular cavity. These earlier adventitious roots arise, like the primary lateral roots, from the protoxylem poles, and in some cases seem to develop in definite acropetal succession. Subsequent to this the appearance of roots is irregular and depends to a certain extent upon the peculiarities of the individual plant, but there are certain conditions which always lead to their development.

Should the main axis become inclined or curved, roots will develop from the convex or under surface. This feature is most marked in the hypocotyl and at the bent nodes; the roots decrease in frequency from below upwards.

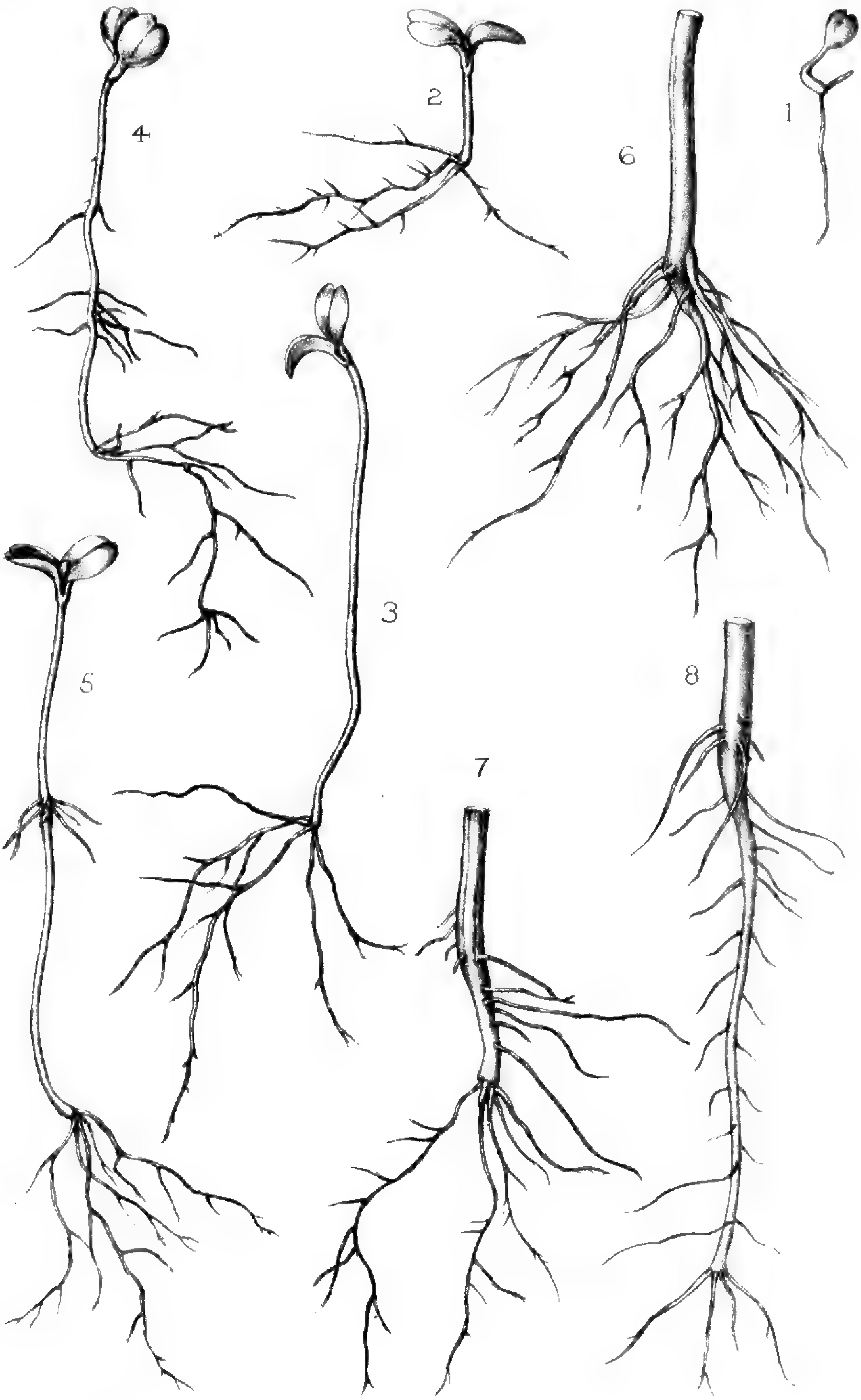
Roots may be produced from robust lateral branches, and here, again, it is from the convex surface of the basal swellings that they develop.

A damp atmosphere is favourable to root-growth, but it is not the primary cause of their development. Soil contact is also a potent factor in stimulating their development.

Adventitious roots, which are usually abortive, invariably arise as the result of wounding, most probably as a response to the interference with the translocation of water and food substances. Their appearance in plants with slit internodes is due to a similar stimulus.

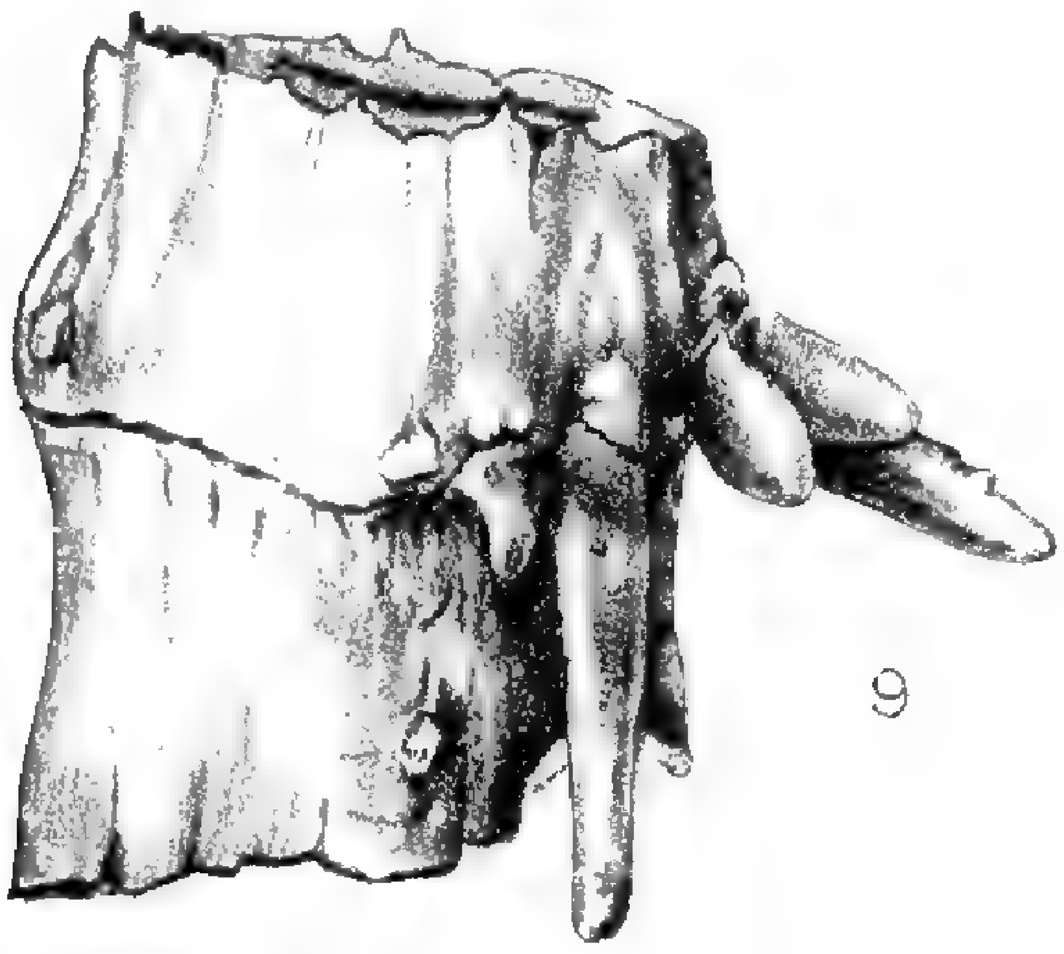
In these two cases the roots develop immediately above the wound or slit whether it be on the concave, convex, or vertical surface of the stem.

The position of the majority of aerial roots makes them necessarily abortive.



I McC. del, Highley, lith. C Hodges & Son. imp

IMPATIENS ROYLEI, Walp.



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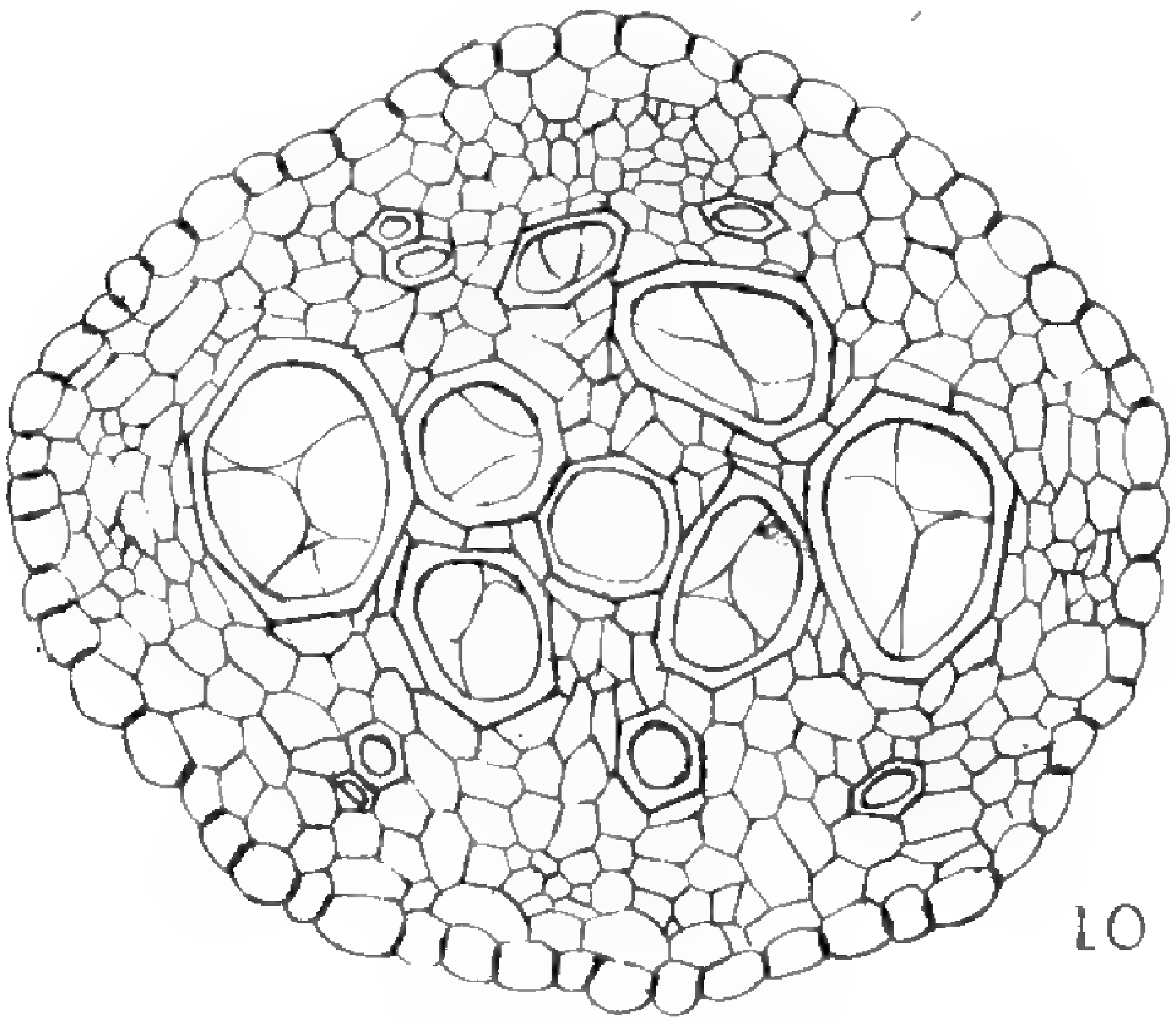

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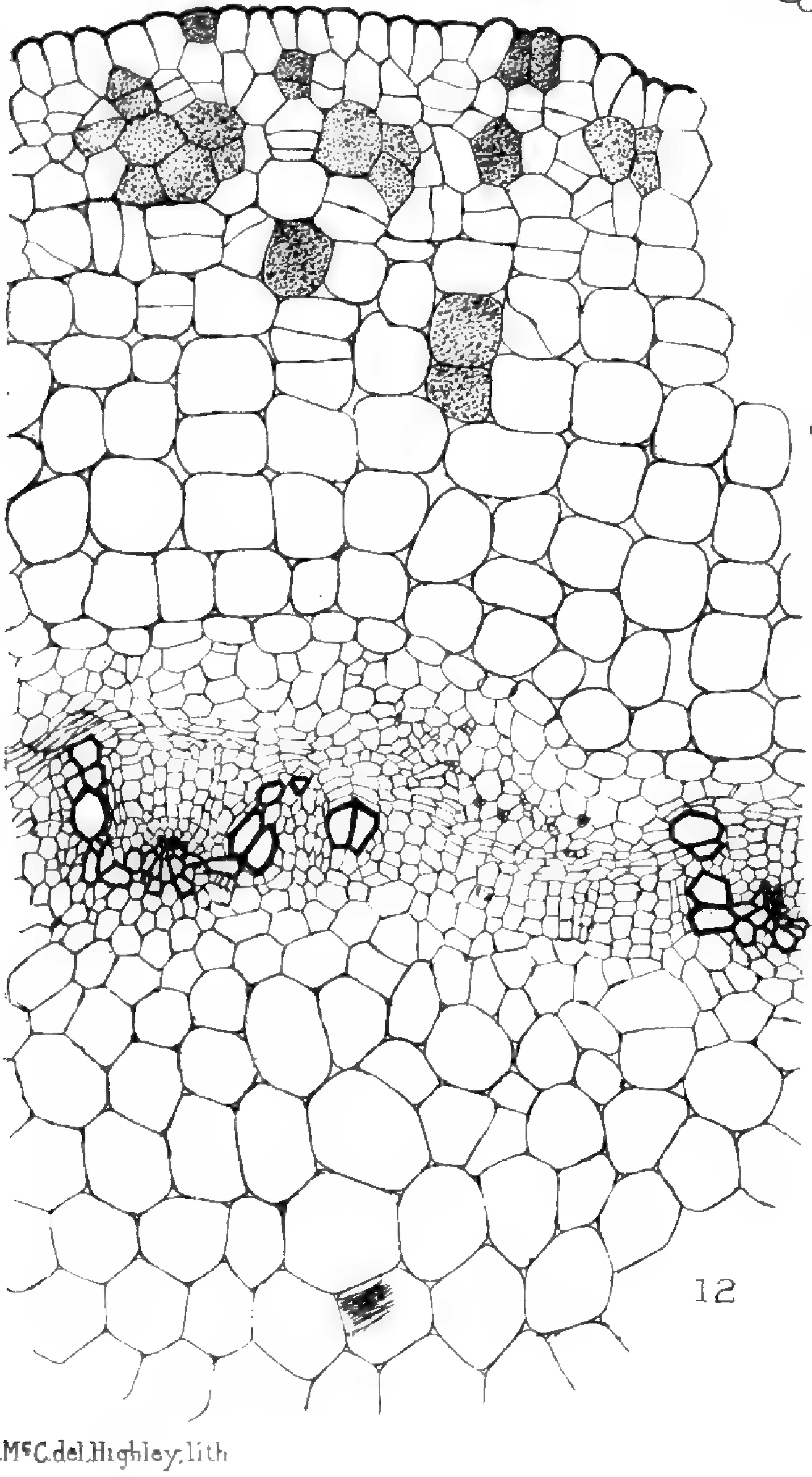

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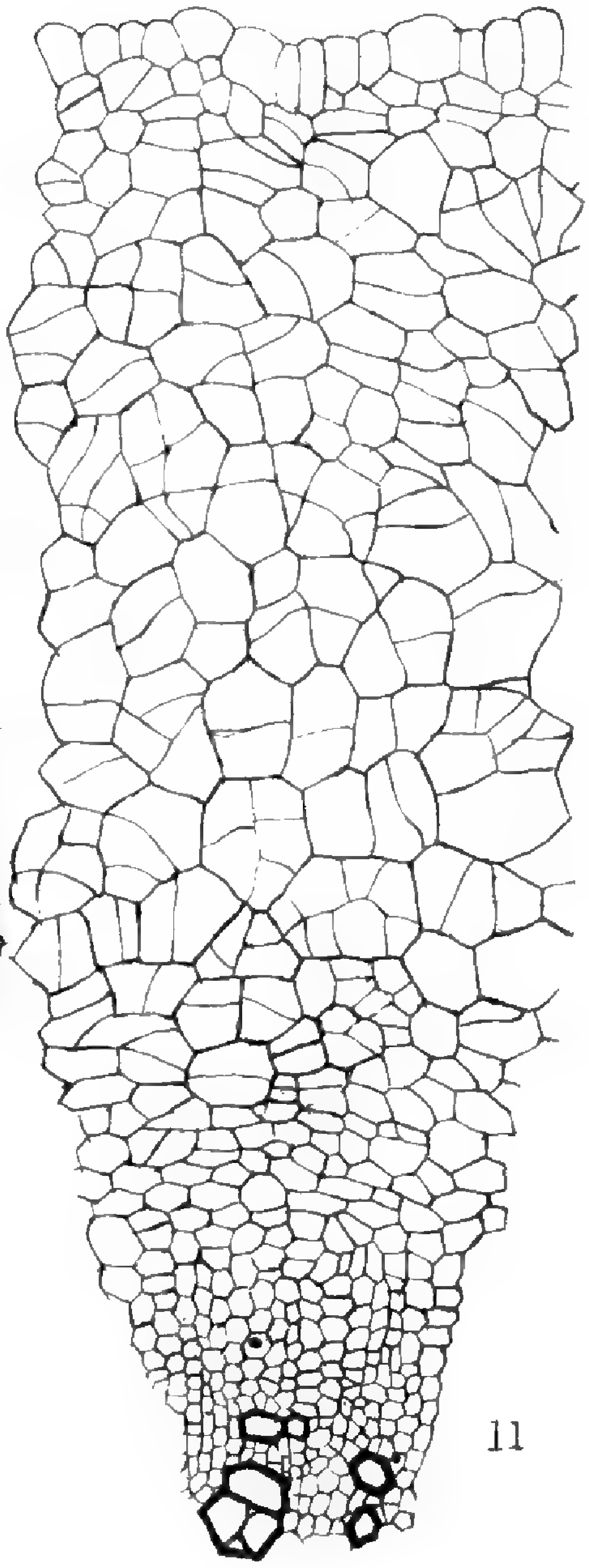

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I.M^cC.del. Highley, lith. C. Hodges & Son, imp.

IMPATIENS ROYLEI, Walp.

They remain short and stunted, and are soon protected by a layer of cork. A marked decrease in diameter, about one-third of the distance from the tip, is a characteristic feature of such abortive roots.

Should these roots, however, be surrounded by soil, they will, like the roots developed from the lower part of the hypocotyl, produce lateral roots freely and will grow to a considerable length.

In the primary root-system the tap-root is tetrarch with a solid xylem ; it may occasionally develop a considerable amount of secondary wood. The lateral roots are generally pentarch or tetrarch, but occasionally triarch. In both main and lateral roots the whole of the cortex cells external to the endodermis become divided and suberised, and in both the vessels become closed by tyloses.

The adventitious roots are polyarch with feeble xylem development and a large pith. Tannin cells are common in the cortex, and also appear, though less frequently, in the pith. Raphid sacs are present in the pith and less frequently in the cortex.

Rootlets rarely arise except from subterranean adventitious roots and from roots which have suffered a severe lateral injury or in which the apex has been removed. In the latter case a little rosette of rootlets is often formed.

The rootlets are usually tetrarch, but they vary considerably and may have from three to twelve xylem poles.

Roots sometimes appear to dichotomise, or to develop three or four apices. This is merely the result of injury to the root-tip and the consequent development of new root-apices from the torn plerome.

In conclusion, I should like to express my thanks to Mr. H. S. Holden, at whose suggestion the work was undertaken, for his constant help and advice, and also to Professor Carr, in whose department the work has been done and who granted every facility for its execution.

EXPLANATION OF THE PLATES.

Plate 37.

Fig. 1. }
2. } Young seedlings showing the primary root-system and the varying length of the hypocotyl.
3. }

4. Seedling with lateral roots of hypocotyledonary origin.

5. Seedling with primary lateral roots arranged in a whorl on the hypocotyl.

6. Primary root-system showing abrupt change in diameter at the junction of the hypocotyl and the tap-root; note that the tap-root is short and the root-system shallow.

7. }
8. } Primary root-systems showing a more gradual change in diameter and the ultimate narrowing of the tap-root.

PLATE 38.

Fig. 9. Adventitious roots developing from a cotyledonous node.

10. Transverse section near the tip of a pentarch tap-root, showing tyloses.

11. Transverse section of a primary lateral root showing cork formation in hypodermal layers of the cortex.

12. Transverse section of an adventitious root showing tannin cells and a raphid sac.

On the Floral Anatomy of some Compositæ. By JAMES SMALL, M.Sc.(Lond.), Lecturer in Botany, Durham University. (Communicated by Prof. M. C. POTTER, M.A., Sc.D., F.L.S.)

(4 Text-figures.)

[Read 30th November, 1916.]

THERE have been numerous observations on the venation of the corolla in the Compositæ (**2**, **4**, &c.); the vascular supply of the ovule (**6**, **8**, **14**, **18**, **19**) and the style (**5**) has also been the subject of enquiries, and there are also records of the structure of the pericarp in many species (**3**, **6**, **7**, **9**); but, except in the Cichorieæ (**15**, **16**, **17**), no complete study of the vascular system of the flower appears to have been made. The observations of Trécul confirm the striking uniformity of the vascular supply of the corolla in the Cichorieæ, which seems obvious from the external examination of the venation of a large number of species and genera belonging to this group. The present investigation deals with the floral anatomy of three typical forms of florets—tubular, ligulate, and bilabiate or pseudo-ligulate. As it has been suggested that the Cichorieæ were derived from the Senecioneæ (**10**, **12**), it was thought that the examination of the linear ray florets in *Tussilago Farfara* might show an intermediate stage between the two groups.

The anterior lip of the labiate or ray floret in the Compositæ is frequently four-lobed, especially where the corolla is broad, as in some species of *Cremanthodium* (*C. rhodocephalum*, Diels, *C. Decaisnei*, C. B. Clarke, *C. reniforme*, Benth., *C. Thomsoni*, C. B. Clarke). The vascular supply is modified accordingly. The corolla may be broad and still only three-lobed, as in *Layia elegans*, Torr. & Gray, or it may be three-lobed with a vascular supply for four lobes, or the lobes may be fused so that the number varies from one to three, while the number of conducting strands remains the same. When the anterior lip is broad the conducting strands tend to increase in number, the simplest modification being the development of three auxiliary strands in the position of the midribs of the three petals. Branching of the strands may take place to a varying degree, and usually occurs in the above-mentioned species of *Cremanthodium* and in many *Senecio* species, as well as in many other cases where the number of main strands remains three or four or by fusion becomes less than three. The number of strands in *S. Doronicum*, Linn., varies from four to eight, and in *S. eubœus*, Boiss. & Heldr., may be as many as eleven, but it may be larger in other species (e. g., *Helianthus* spp.).

The vascular system of the ovule has been the subject of many observations and some controversy, but it does not seem to have any bearing on the problems of phylogeny. The occurrence of anomalous biovulate and

bilocular ovaries in the typical genus of the order (**13**) is much more illuminating. The vascular supply of the corolla, on the other hand, seems to furnish a means of distinguishing between the bilabiate and the ligulate types of corolla in certain cases where the distinction is not obvious. *Tussilago* is one of these. The ray florets are very numerous and form several rows, enclosing a relatively small number of male disc florets. Without a detailed examination of the conducting tissue it seemed possible that this was a truly ligulate corolla with the five teeth at the tip completely fused or aborted.

Senecio vulgaris may be taken as a species with a typical tubular floret, and a brief description of the conducting tissue of these florets will furnish a basis for comparisons. A model of the vascular system was constructed, of which fig. 1 is a sketch; the conducting strands of the stamens are indicated by thin lines, and those of the ovule and style by dotted lines. In fig. 1 the lines by the side indicate the position of the sections with the corresponding numbers in fig. 2, and the position of the axis is indicated by an arrow. The diagrams in fig. 2 are so orientated that the posterior part of the flower is at the left, and the shaded regions in diagrams 5, 6, and 15 indicate the position of the nectary. The conducting tissue is composed of a few vessels and numerous elongated cells with more or less lignified walls.

A single strand from the receptacle enters the flower and spreads at the base of the ovary, giving what may be called the *lower distributive centre* (fig. 2, diag. 1). From this more or less disc-shaped mass ten bundles are given off to supply the wall of the ovary (fig. 2, diag. 2) and a single bundle to supply the ovule. Towards the top the ten bundles fuse in pairs (fig. 2, diag. 3), and a little higher up there is a series of anastomoses constituting an *upper distributive centre* (fig. 2, diag. 4). From this centre are given off five bundles, which alternate with the fused petals (fig. 2, diag. 5), and a short distance above the zone of anastomoses divide tangentially to supply the stamens and corolla (fig. 2, diag. 6). The staminal bundles remain near the corolla bundles within the tissue of the corolla-tube until the filaments are differentiated (fig. 2, diag. 7), and they end in the connectives (fig. 2, diag. 8). The two bundles of the style are given off from the upper distributive centre (fig. 2, diag. 5), and the anastomosing of the five main bundles in this region is probably required on account of the want of symmetry, five strands dividing to give the two stylar and five corolla strands. Trécul (**15**) finds that in the Cichorieæ the stylar bundles are usually inserted upon the lateral bundles of the ovary, but he remarks on the variation shown and does not seem to have observed the upper and lower distributive centres.

The lower distributive centre can be compared to the region of fusion in *Parnassia*, and the "raison d'être" of the complications of the upper distributive centre is evidently somewhat similar to that suggested by

Arber (1) for the fusion in that genus. In *Tussilago Farfara*, where there is more symmetry, the upper distributive centre is much less complicated.

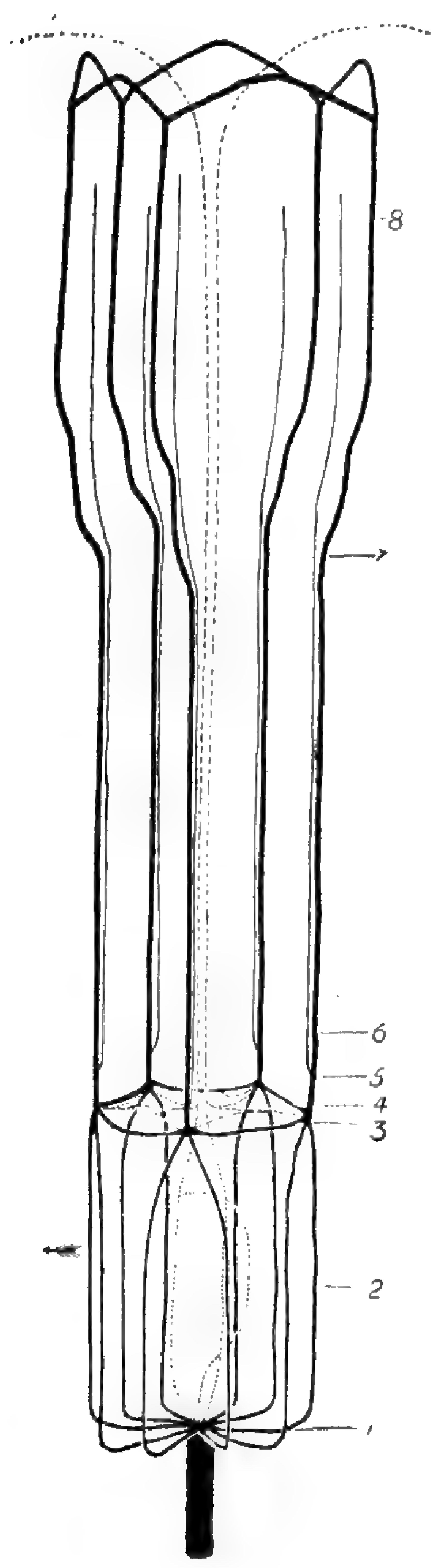

FIG. 1.—Vascular system of tubular floret of *Senecio vulgaris*.

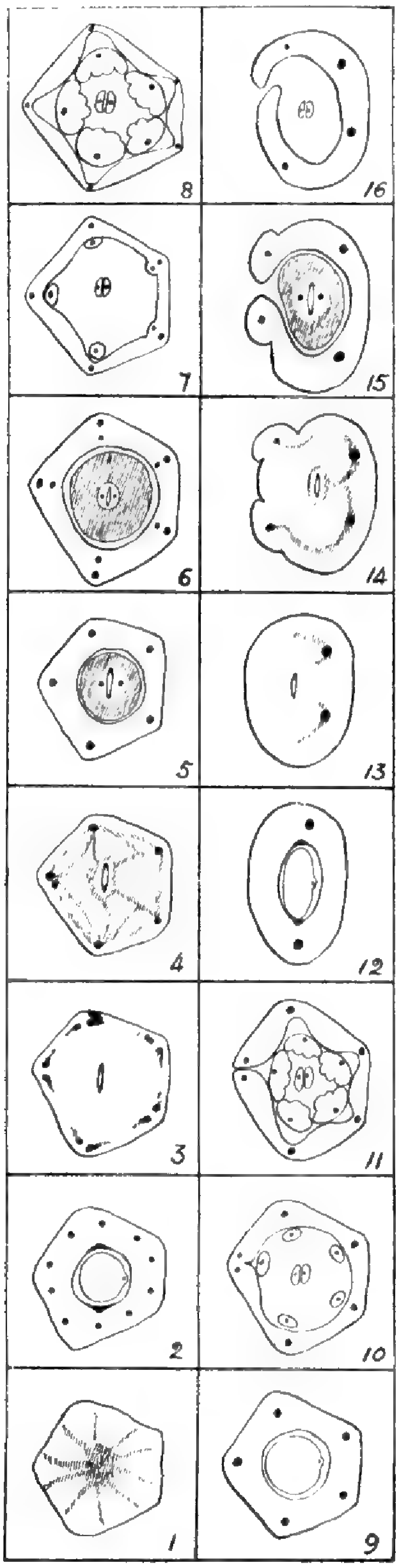

FIG. 2.—Semi-diagrammatic sections of the florets of *Senecio vulgaris* (diags. 1–8), *Taraxacum officinale* (diags. 9–11), *Calendula officinalis* (diags. 12–16).

As both Brown (**2**) and Don (**4**) remark on the facility with which the embryo can be extracted from the ovary adherent to the two strands which supply the style and which, according to these authors, continue without a break down the wall of the ovary, all the material was examined specially for such bundles. The stylar canal is lined with elongated cells and these become lignified and persist on the lateral sides of the mature ovary as conducting strands (fig. 2, diags. 2–3), but seem to act only secondarily as conducting tissue. Brown (**2**) gives the orientation of the stylar bundles correctly as antero-posterior and describes the ovarial strands as lateral. The lateral position of these strands, which are not a part of the true vascular system, is due to the developing embryo bursting the stylar canal on the anterior and posterior sides. The five corolla bundles divide at the base of the corolla lobes, and the halves unite to form five arches of conducting tissue along the margins of the lobes.

In *Taraxacum officinale*, an example of the ligulate type, the course of events is very similar. The primary strand from the receptacle divides only into five * strands and the ovular supply (fig. 2, diag. 9). In this case the cells lining the stylar canal do not become lignified, and there is no trace of the bundles referred to by Brown and Don. There are again the upper and lower distributive centres, and a short distance from the former the posterior strand divides into three (fig. 2, diag. 10). The inner strand supplies the posterior stamen and the other two supply the margins of the ligulate corolla (fig. 2, diag. 11). According to Trécul (**15**) the point of fusion of these two marginal bundles varies from the upper distributive centre to some distance above the top of the ovary.

In the ray or bilabiate florets of *Calendula officinalis* the single primary strand divides soon after or even before it leaves the receptacle, giving two large bundles and the ovular supply (fig. 2, diag. 12). Fusions begin towards the top of the ovary (fig. 2, diag. 13). The upper distributive centre shows new features (fig. 2, diag. 14) obviously dependent upon the absence of a posterior bundle, and from this centre arise the two stylar bundles, the two main corolla bundles, and two subsidiary corolla bundles (fig. 2, diags. 15 & 16). The cells lining the stylar canal become lignified and persist as in *Senecio vulgaris* (fig. 2, diags. 12 & 13). The stamens are absent, and there is no trace of the bundles which presumably supplied them in the hermaphrodite condition of the floret. It is uncertain to what extent the vascular system of the bilabiate floret in *Calendula officinalis* is typical of ray florets in general.

The disc florets of *C. officinalis* are very similar to those of *Senecio vulgaris*, except that only five bundles and the ovarial supply originate from the lower distributive centre instead of ten as in the latter species.

* Trécul (**16**) gives usually four, rarely five, bundles.

Considering now the anatomy of the bilabiate florets in *Tussilago Farfara*, we find the same primary bundle as in *Senecio vulgaris* and *Taraxacum officinale* (fig. 4, diag. 1) and the same lower distributive centre (fig. 4, diag. 2). The bundle at this stage in *T. Farfara* is more clearly defined than in the other cases, being a well-marked disc from the interior of which arise five strands, four to supply the periphery of the ovary and the fifth to supply the ovule (fig. 4, diags. 3 & 4). The anterior bundle is usually larger than the others, even at this stage. There is some variation in the number of the peripheral bundles, five occurring frequently and the number may increase to six, seven, or eight. All these fuse at the upper distributive centre, and above that point four is the constant number. The upper distributive centre is clearer and shows more symmetry than in the other species examined. There are two well-defined arcs with the lateral bundles in the centres of the arcs; these two arcs are joined at their anterior and posterior ends by two shorter arcs with arms forming sectors (fig. 4, diag. 5). From the points of the sectors arise the two stylar bundles (fig. 4, diag. 6). At this stage the somewhat rudimentary pappus shows many interesting stages in the "splitting" of this solid ring of tissue into the numerous hairs of the mature pappus, which are multicellular at their bases, but split higher up into hairs which are unicellular in cross-section. The pappus has no vascular supply.

The posterior bundle soon comes to an end, and the corolla remains a tube with three conducting strands (fig. 4, diag. 7). The lateral strands continue in a very attenuated form, supplying the margins of the corolla after the tube splits to give a distinct lip (fig. 4, diag. 8) *. The style remains unbranched up to this point, but higher up it branches and the conducting strands become merged in the elongated cells of the layer below the stigmatic papillæ (fig. 4, diag. 9). Beyond the style the lip becomes flattened (fig. 4, diag. 10), and the anterior bundle extends almost to the tip of the corolla. The cells lining the stylar canal become lignified; the stylar canal is burst on the anterior and posterior sides by the developing embryo and the lignified cells persist after the degeneration of the surrounding parenchyma, forming two secondary conducting strands one on each side of the embryo (fig. 4, diag. 3). These strands are more conspicuous in this species than in most, and Brown (2, p. 89) mentions *Tussilago odorata* † as another species in which these "cords" are easily separable from the "ovarium."

Fig. 3 shows the complete vascular system, and this figure and the diagrams of fig. 4 are arranged so that the posterior side is at the left as in figs. 1 & 2.

* In the few cases where there are two main bundles in the anterior lip, one of these is shown by the examination of serial sections to be an abnormally well-developed lateral bundle and the symmetry in the corolla-tube is of the usual form.

† Probably *Petasites fragrans*, Presl.

The male disc florets of *Tussilago Farfara* are tubular ; the style persists as a pollen presenter, and it is interesting to note in connection with the explanation given by Arber (1) of the vestigial bundles in *Parnassia* that there are *four* vascular bundles in the styles of these florets where the

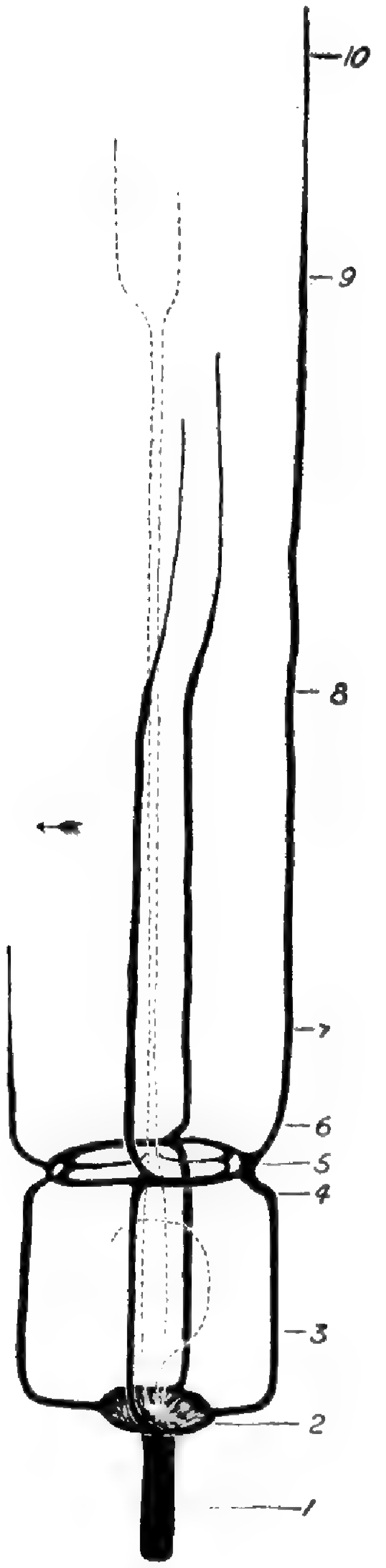

Fig. 3.—Vascular system of ray floret of *Tussilago Farfara*.

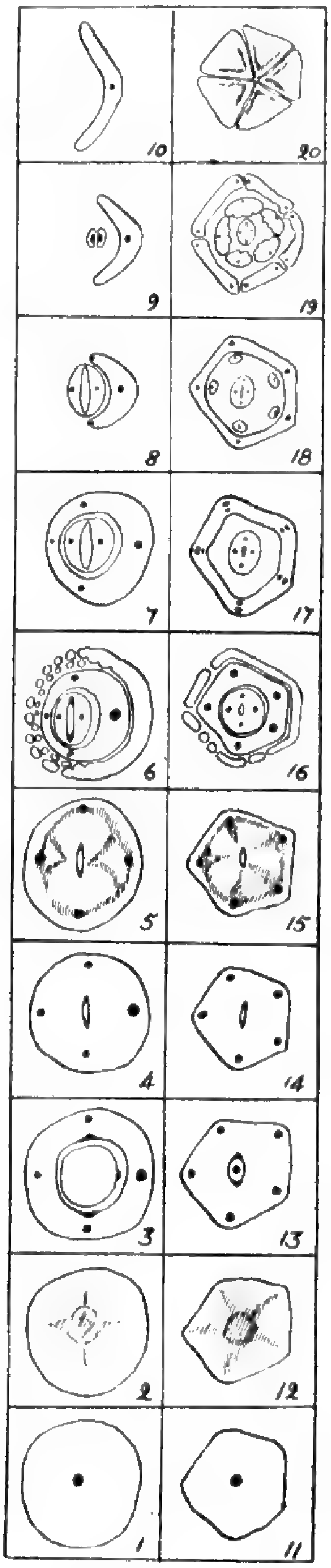

Fig. 4.—Semi-diagrammatic sections of the ray florets of *T. Farfara* (diags. 1–10) and of the disc florets (diags. 11–20).

original function of the style has been lost and a secondary function acquired, which requires, if anything, more rigidity in the style than does the original function *. A similar case is that of *Arctotis aspera*, previously reported on (**11**) in connection with an irritable pollen-presentation mechanism. Here the comparatively thick style remains upright and undivided during the male stage, and an examination of hand-sections shows the presence of four vascular bundles in the lower half of the thick part of the style. The two lateral bundles end near the separation of the style branches.

The lower distributive centre in these male florets of *T. Farfara* (fig. 4, diag. 12) is similar to that in the ray florets, but the ring is not so well marked and only an abbreviated vestige of the ovule remains (fig. 4, diag. 13). In the upper distributive centre (fig. 4, diag. 15), which is also similar, the two lateral bundles supply the two lateral stylar bundles; the two anterior bundles supply the anterior stylar bundle; and the posterior bundle supplies the posterior stylar bundle. The cavity of the ovary persists, as do the strands of the stylar canal (fig. 4, diags. 13 & 14). The short pappus is a single row of laciniæ, not a double row as in the ray florets (fig. 4, diags. 6 & 16). The five lobes of the corolla are longer than in *Senecio vulgaris* (fig. 2, diag. 8 & fig. 4, diag. 19), and the tips of the lobes show the same fusion of the divided strands (fig. 1 & fig. 4, diag. 20) as in the latter species. The four stylar bundles end near the base of the aborted stigmatic region.

It will be seen from the foregoing account that, while the anatomy of the ray florets in *Tussilago Farfara* differs considerably from that of the ray florets of *Calendula officinalis*, it shows no similarity to that of the ligulate type which is so constant a feature of the Cichorieæ. The constancy of the one particular type of floral anatomy in the Cichorieæ thus enables us to eliminate definitely *Tussilago Farfara* as an intermediate type. The vascular supply of the bilabiate corolla seems to vary with the width of the anterior lip, and the single main strand of the very narrow lip in *Tussilago Farfara* is to be considered with the other variations mentioned, such as the increase in number of the bundles when the anterior lip is wide, as developed in response to the needs of the corolla.

Acknowledgments are due to Professor M. C. Potter for access to books and periodicals.

* A curious difference between these male florets and the female ray florets is the very complete protective modification of the free margins of the petals. In the male florets the marginal epidermal cells are elongated to form tooth-like protuberances which in the bud fit exactly into those of the adjacent margins even up to the extreme tips of the five lobes, while no such protective device is present in the ray florets, where from a very early stage the style is free and unprotected by the corolla. This may be due to the archesporium being the region which requires protection.

Summary.

1. The vascular anatomy of the tubular florets of *Senecio vulgaris*, the ligulate florets of *Taraxacum officinale*, and the tubular and bilabiate florets of *Calendula officinalis* and *Tussilago Farfara* are described in detail.

2. The vascular supply of the ray florets of the last species is discussed, and any suggestion of *T. Farfara* being a type intermediate between the Senecioneæ and Cichorieæ is negatived.

3. The conclusion is reached that the ligulate florets of the Cichorieæ have a comparatively constant type of vascular anatomy; that the tubular disc-florets show a slightly greater variability, while the variation in the vascular anatomy of the bilabiate ray florets is so great that they can be distinguished from the first two classes by the floral anatomy alone.

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